Process Specification for the Qualification of Manual Arc Welders

Engineering Directorate

Manufacturing, Materials, and Process Technology Division

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REVISIONS		
VERSION	DESCRIPTION	DATE
Baseline	Original version	9/21/97
A	Change process owner, rewrote numerous sections to clarify, rewrite section 6.4 to remove allowance for use of workmanship qualification testing on pressure systems hardware, and to add examination and testing requirements.	07/19/99
B	Various editorial changes, rewrite 3.0, expand 5.2, amended footnotes in Tables 6.3.1, 6.3.3 and 6.3.4, added 4G-I plate qualification position to Table 6.3.1, rewrite 6.4 for clarification, combined 6.6 and 6.6.1, rewrite 6.7.I for simplification and clarification, added 4G-I sketch to Figure A4, modified figures A1 and A2.	03/24/2000
C	Periodic ISO review. Various editorial corrections and changes. Added reference to ANSI/AWS D17.1. Add to table 6.2.1 alternate acceptance test for fillet weld qualification.	02/12/2004

1.0 SCOPE

This process specification provides the minimum requirements that govern the testing and qualification of manual arc welding (includes semi-automatic processes) personnel. Procedural and quality assurance requirements are given. All work instructions and Welding Procedure Specifications (WPS) used during welder qualification shall satisfy the requirements of this process specification and its applicable documents.

2.0 APPLICABILITY

This specification applies to the qualification of manual arc welding personnel (welders) who fabricate, repair, or install welded hardware under the authority of NASA/JSC. Welders successfully qualifying under this Process Specification (PRC) shall receive certification for the manual arc welding of pressurized or structural hardware, both flight and non flight as applicable to the type and scope of the test(s) passed.

2.1 APPLICABLE PROCESSES

The following processes and any pulsed derivatives thereof are governed by this specification:

a) Gas Tungsten Arc Welding (GTAW).
b) Gas Metal Arc Welding (GMAW).
c) Flux Cored Arc Welding (FCAW)
d) Plasma Arc Welding (PAW).
e) Shielded Metal Arc Welding (SMAW).

3.0 USAGE

This process specification is considered to meet or exceed the intent of the major recognized industry and government standards for welder performance qualification. Therefore, vendors preparing to weld hardware for NASA/JSC that have existing personnel with applicable and currently valid qualifications/certifications to AWS, ASME, SAE/AMS or U.S. government standards for welder performance qualification, for which qualification and continuity records are available and qualifications are current, shall be considered acceptable for use where this PRC is invoked. Qualifications/certifications are considered not transferable therefore, welders that are newly hired by NASA/JSC or one of its contractors, shall be tested in accordance with this PRC. Following an interruption to employment, welders rehired to the same organization within 6 months from the last verification of a certification being current, shall not be required to recertify at the discretion of the qualifier.

3.1 WORK INSTRUCTIONS

Work instructions shall be generated for implementing this process specification. The work instructions shall contain sufficient detail to ensure that the skills performance testing process produces consistent, repeatable results that comply with this specification. At JSC, these work instructions are approved as Detailed Process Instructions (DPIs) that describe in a detailed, step-by-step format the required procedures, equipment, and materials to be used for conducting a given process.

If the skills performance testing process is to be performed by an outside vendor, work instruction development shall be the responsibility of the vendor. The contractor shall ensure that the work instructions meet the requirements of this process specification.

3.2 WELDING PROCEDURE SPECIFICATION

All Welder Performance Qualification (WPQ) testing shall be conducted using a qualified WPS. However, the qualification of a welder and the qualification of a WPS can be conducted concurrently, but in the event that the WPS qualification test results are unsatisfactory, the WPQ test shall be considered invalid.

4.0 REFERENCES

The standards listed below shall be considered a part of this specification where applicable. Where there is a conflict, this document shall take precedence. Unless otherwise indicated, the revision that is in effect on the date of invitation for bids or the date of request for proposals shall apply.

a. American Society of Mechanical Engineers

ASME/ B&PV Code *Section IX, Welding and Brazing Qualifications*

b. American Society for Testing and Materials

ASTM E1417 *Liquid Penetrant Examination, Standard Practice for*

ASTM E1444 *Magnetic Particle Examination, Standard Practice for*

ASTM E1472 *Radiographic Examination, Standard Practice for*

c. American Welding Society (AWS)

ANSI/AWS A2.4 *Standard Symbols for Welding, Brazing and Nondestructive Testing*

ANSI/AWS A3.0 *Standard Welding Terms and Definitions*

ANSI/AWS B2.1 *Standard for Welding Procedure and Performance Qualification*

ANSI/AWS D17.1 *Specification for Fusion Welding for Aerospace Applications*

ANSI/AWS QC-1 *Standard for AWS Certification of Welding Inspectors*

d. NASA/Johnson Space Center

SOP-007.1 *Preparation and Revision of Process Specifications (PRC)*

PRC-6503 *Process Specification for Radiographic Inspection*

PRC-6505 *Process Specification for Magnetic Particle Inspection*

PRC-6506 *Process Specification for Liquid Penetrant Inspection*

TI-0000-04 *Training Instructions for the Welding Processes*

NAVSEA

S9074-AQ-GIB-010/248 *Requirements for Welding and Brazing Procedure and Performance Qualification*

f. SAE/AMS

AMS-STD-1595 *Qualification of Aircraft, Missile and Aerospace Fusion Welders*

5.0 GENERAL REQUIREMENTS

Qualification under this PRC requires completion of a specified test weldment and acceptance by the qualifier of the test weldment and test results. The welder qualification is limited by the essential variables given for each welding process as listed in Section 6.3. Acceptance of performance qualification weldments is allowed by either of two methods:

a) Qualification by standard test (Section 6.2) or,
b) Qualification by workmanship test (Section 6.4).

Performance qualification by standard test shall qualify the individual to perform welding where qualification by either standard test or workmanship test is specified, but not vice versa.

5.1 QUALIFICATION RESPONSIBILITY

Each manufacturer or contractor (i.e., a fabricator, assembler or an installer is included in this premise) is ultimately responsible for conducting tests to qualify the skill performance of welders in accordance with a qualified WPS which that organization employs in the fabrication of weldments.

The welder undertaking performance qualification tests shall be under the supervision and control of a qualifying party (herein referred to as “qualifier”) during the welding of test weldments. The extent of supervision and control shall be at the discretion of the qualifier with due consideration given to any and all possible factors that may adversely affect the integrity of the process activity governed by this PRC. Acceptance, rejection, qualification, disqualification and documentation of test results is the responsibility of the qualifier.

The qualifier shall have appropriate qualifications and experience in code governed welding related activities. A preferred credential is certification as a welding inspector (e.g., American Welding Society CWI), but not required. Performance qualification documentation shall be signed (certified) and dated by the qualifier.

It is permissible to subcontract any or all of the work for preparation of test materials prior to welding and subsequent work on the preparation of test specimens from the completed weldments, performance of nondestructive examination and mechanical tests. However, the qualifier shall be ultimately responsible for the validity and accuracy of the work performed to support the process activities performed under this PRC.

5.2 VISION REQUIREMENTS

Vision acuity is considered essential to the proper execution of welding processes. Therefore, at a minimum, welder candidates shall be tested and their vision shall meet the following minimum conditions in each eye (natural or corrected): 1) for long distance, better than 20/30 and, 2) for sixteen (16) inches distance, permits reading of Jaeger No. 2 type. Failure to meet this minimum level of vision acuity shall be substantial cause to 1) reject a candidate for performance qualification testing or, 2) revoke a current certification or, 3) refuse recertification. Other vision acuity tests determined by a qualified and licensed medical professional to be equivalent to the above shall also be acceptable.

Welders shall be tested yearly to ensure that these vision requirements are maintained. The examination (testing) shall be administered by an Ophthalmologist, Optometrist, Medical Doctor, Registered Nurse, or by any ophthalmic or medical personnel (e.g., EMT, LVN, paramedic, Certified Physician's Assistant, etc.) qualified and licensed to administer these specific exams. Records of these tests shall be made available to the qualifier upon request. When corrective aids are used for the vision test, equivalent aids shall be used for production welding.

5.3 IDENTIFICATION OF WELDERS

The contractor shall assign a unique number or other identification to each welder upon their initial qualification and is responsible for maintaining welder identification records including the date of assignment of these numbers. The identification shall be traceable to an employee number, social security number, or other information that is unique to that person to ensure there is no duplication of assignment of numbers/identifications during the same period of employment.

6.0 TESTING REQUIREMENTS

The performance qualification tests are intended to determine the ability of welders to make sound welds. Qualification tests shall be conducted using a qualified WPS, except that when performance qualification is done in accordance with a WPS that requires a preheat or postweld heat treatment, and destructive testing will not be used, these postweld processes may be omitted.

6.1 TEST RECORDS

For each welder, the contractor shall complete a WPQ test record containing the essential variables, type of tests and results, and the ranges qualified in accordance with the applicable sections of this specification. Suggested formats for these test records is given in Appendix A, Figures A1, A2, and A3. However, any reasonable method of maintaining these records is considered acceptable provided the necessary data is recorded and the records are readily accessible upon request.

6.2 QUALIFICATION BY STANDARD TEST

Performance qualification by standard test shall be in accordance with the examination requirements of Section 6.2.1. Qualification by standard test requires completion of a standard test weldment that meets the essential variable requirements of Section 6.3

and be welded in accordance with a qualified WPS. Test weldments shall satisfy the applicable acceptance criteria of Section 6.7.

6.2.1 Examination Requirements

Except for the special requirements of Section 6.4, each welder who welds under the rules of this specification shall have passed the visual and mechanical examinations prescribed in Section 6.7 as applicable. The examination requirements shall be in accordance with Table 6.2.1, except that the length of weld required for qualification by radiographic examination shall be in accordance with Section 6.7.3.

Welders making a groove weld test coupon using FCAW, GMAW (except with the short-circuiting arc mode), GTAW, PAW, or SMAW, or a combination of these processes, may be qualified by radiographic examination, except for Material Group Numbers 2X (Aluminum), 5X (Titanium), and 6X (Zirconium) metals. However, welders qualifying on base material(s) in Group Numbers 2X (Aluminum) or 5X (Titanium) with the GTAW and/or PAW processes may be qualified by radiographic examination. Performance qualification for the GMAW process using the “short-circuiting arc” mode shall always require bend testing except as specified in Section 6.4.

Table 6.2.1

Examination Requirements - Qualification By Standard Test

	Pipe or Plate	
Examination / Testing	**Groove**	**Fillet**
Visual Examination	Yes	Yes
Radiographic Examination	Yes (1)	--
Guided Bend Test	Yes (1)	--
Fillet Weld Shear Test	--	Yes (2)
Fracture Test	--	Yes (2)
Macro Examination	--	Yes

(1) Either radiographic examination or guided bend test may be performed.

(2) Either fillet weld shear test or fillet fracture test may be performed.

6.3 ESSENTIAL VARIABLES

A welder qualified to weld in accordance with one qualified WPS is also qualified to weld in accordance with other qualified WPSs, using the same welding process, within the limits of the essential performance welding variables. A change in the essential variables as specified below will require additional performance qualification by the welder:

a) A change in the welding process.
b) The deletion of backing (The term “backing” shall mean metallic or non metallic materials in any form or back welding at any stage of welding the joint.).
c) The deletion of auxillary shielding gas (e.g., trailing gas) or root side shielding gas where it is a WPS requirement, except for joints welded from both sides.
d) A change in the welding position except as allowed by Section 6.3.1.

e) A change in the weld metal thickness or tube/pipe diameter range beyond that for which the welder is qualified (Section 6.3.2).
f) A change in the base metal (M-No.) except as allowed by Section 6.3.3.
g) A change in the filler metal (F-No.) except as allowed by Section 6.3.4.
h) A change in vertical welding progression, upward or downward, except for final dress passes (cap passes).
i) Except for SMAW, a change from AC to DC, or vice versa, or a change in DC polarity.
j) For GMAW, a change from the standard mode (spray arc, globular arc, or pulsed arc) to the short circuiting arc mode, or vice versa.
k) For PAW, a change from transferred arc mode to the non transferred arc mode, or vice versa.
l) For GTAW and PAW, the addition or deletion of filler metal or consumable inserts.

6.3.1 Position

The positions for which a welder becomes qualified when successfully completing a test weldment in one or more of the positions illustrated in Appendix A, Figures A4, A5, A6, and A7 are shown in Table 6.3.1.

6.3.2 Thickness and Diameter

The thickness, and diameter where applicable, of a groove weld or fillet weld test weldment shall be based upon the weld thicknesses and diameters to be welded in production. For groove welds, Table 6.3.2 (a) shows the ranges qualified by a given test weldment thickness and Table 6.3.2 (b) shows the ranges qualified by a given test weldment diameter. For fillet welds, Table 6.3.2 (c) shows the ranges qualified by a given plate test weldment thickness and Table 6.3.2 (d) shows the ranges qualified by a given test weldment diameter. Any groove weld qualification shall also qualify a welder for fillet welds of any base material thickness, fillet sizes and diameters.

6.3.3 Base Metals

Qualification shall be performed with a base metal(s) from the same base metal group(s) to be used in production, which shall qualify only for base metals under the same M Number (see Appendix C), except that some base metals qualify for other base metals as specified in Table 6.3.3.

6.3.4 Filler Metals

Qualification shall be performed with a filler metal(s) from the same filler metal group to be used in production, which shall qualify only for filler metals under the same F Number (see Appendix B), except that some filler metals qualify for other filler metals as specified in Table 6.3.4.

Table 6.3.1
Welding Position and Diameter Limitations

Qualification Test		Position and Type Weld Qualified (1)		
		Groove		Fillet
Weld	Position	Plate & Tube/Pipe over 24" OD	Tube/Pipe less than 24" OD	Plate & Tube/Pipe
Plate - Groove	1G	F	---	F
	2G	F, H	---	F, H
	3G	F, V	---	F, H, V
	4G	F, O	---	F, H, O
	3G and 4G	F, V, O	---	All
	2G, 3G, and 4G	All	---	All
	3G and 4G-I(4)	All	---	All
Plate - Fillet	1F	---	---	F (2)
	2F	---	---	F, H (2)
	3F	---	---	F, H, V (2)
	4F	---	---	F, H, O (2)
	3F and 4F	---	---	All (2)
Pipe – Groove(3)	1G	F	F	F
	2G	F, H	F, H	F, H
	5G	F, V, O	F, V, O	All
	6G	All	All	All
	2G and 5G	All	All	All
Pipe – Fillet(3)	1F	---	---	F
	2F	---	---	F, H
	2FR	---	---	F, H
	4F	---	---	F, H, O
	5F	---	---	All

Notes:

(1) Positions of welding as shown in Appendix A, Figures A4, A5, A6, and A7.
F= Flat, H= Horizontal, V= Vertical, O= Overhead

(2) Tube/pipe 2 $^{7}/_{8}$ " and over.

(3) Square (box) tubing flat-to-flat dimension shall be considered the "OD".

(4) 4G-I means "4G Inclined". This term is used to describe a position which closely simulates both the overhead and horizontal positions. The plate is oriented in the overhead position except that the torchside of the plate is inclined to $45^{O} \pm 5^{O}$, about the axis of the weld joint.

Table 6.3.2 (a)
Thickness Limits and Test Specimens - Groove Welds

Bend Specimens	Thickness (T) of Test Coupon	Thickness (T) Range Qualified		Type and Number of Tests Required (Guided Bend)		
		Minimum	Maximum	Side Bend	Face Bend	Root Bend
Transverse	≤ 3/8"	½ T	2 T	Note (1)	2	2
(In the 5G or 6G Position)		½ T	2 T	Note (1)	2	2
Transverse	> 3/8" and < ¾"	½ T	2 T	Note (1)	2	2
(In the 5G or 6G Position)		½ T	2 T	Note (1)	2	2
Transverse	≥ ¾"	½ T	unlimited	4	n/a	n/a
(In the 5G or 6G Position)		½ T	unlimited	4	n/a	n/a
Longitudinal	Any	½ T	2 T	--	1	1

(1) - A side bend may be substituted for each of the required face and root bend tests.

Table 6.2.1 (b)
Groove Weld Diameter Limits

Outside Diameter(1) of Test Coupon, in	OUTSIDE DIAMETER QUALIFIED, in	
	Minimum	Maximum
< 1"	size welded	unlimited
≥ 1" but < 2-7/8 "	1"	unlimited
≥ 2-7/8 "	2-7/8 "	unlimited

(1) Square (box) tubing flat-to-flat dimension shall be considered the "OD".

Table 6.2.1 (c)
Thickness Limits and Test Specimens - Fillet Welds (Plate)

Type of Joint	Thickness (T) of Test Coupon as welded	Range Qualified	Type and Number of Tests Required	
			Macro	Fracture
Tee Fillet	≥ 3/16" and ≤ 3/8"	All base material thicknesses, fillet sizes, and diameters 2-7/8" OD and over	1	1
Tee Fillet	< 3/16"	T to 2T base metal thickness. T maximum fillet size, and all diameters 2-7/8" OD and over	1	1

Table 6.2.1 (d)
Small Diameter Fillet Weld Test

Outside Diameter[1] of Test coupon	Minimum Outside Diameter Qualified	Thickness Qualified
< 1" OD	Size welded	Unlimited
≥ 1" but < 2-7/8" OD	1"	Unlimited
≥ 2-7/8" OD	2-7/8"	Unlimited

[1] Square (box) tubing flat-to-flat dimension shall be considered the "OD".

Table 6.3.3
Allowable Test Weldment Base Metal Groups (M-Numbers) (3)

Base Metal M-Number(s) Used for Welder Qualification Test (1)	Qualifies for Base Metal M-Number(s)
M-No. 1 through M-No. 11 or M-No. 41 through M-No. 47	M-No. 1 through M-No. 11, M-No. 41 through M-No. 47, and any unassigned base metals of similar chemical composition to these metals.
M-No. 12	M-No. 12 only (2)
M-No. 13	M-No. 13 only (2)
M-No. 21, 22, 23, or 25	M-No. 21, 22, 23, or 25
M-No. 26	M-No. 26 only (2)
M-No. 31 through M-No. 35	M-No. 31 through M-No. 35
M-No. 48	M-No. 48 only (2)
M-No. 51, 52, 53 or M-No. 61, 62	M-No. 51, 52, 53 and M-No. 61, 62
M-No. 55	M-No. 55 only (2)
M-No. 81	M-No. 81 only (2)
M-No. 91	M-No. 91 only (2)

Notes:

(1) Performance qualification tests using a base metal not listed in Appendix C shall qualify only for that base metal.

(2) Each base metal in this M-Number group will require individual qualification.

(3) M-Number base metal alloys are as follows:

M-No. 1 thru M-No. 13 - Steel and Steel Alloys
M-No. 2X - Aluminum and Aluminum-Base Alloys
M-No. 3X - Copper and Copper-Base Alloys
M-No. 4X - Nickel and Nickel-Base Alloys
M-No. 5X - Titanium and Titanium-Base Alloys
M-No. 6X - Zirconium and Zirconium-Base Alloys
M-No. 81 - Cobalt and Cobalt-Base Alloys
M-No. 91 - Magnesium and Magnesium-Base Alloys

Table 6.3.4
Allowable Test Weldment Filler Metal Groups (F-Numbers) (3)

Filler Metal F-Number(s) Used for Welder Qualification Test (1)	Qualifies for Filler Metal F-Number(s)
Any F-No. 1 through F-No. 4 (with backing)	The F-Number used in test weldment and any lower F-Number, with backing only.
Any F-No. 1 through F-No. 4 (without backing)	The F-Number used in test weldment with or without backing and any lower F-Number, with backing only.
Any F-No. 5 (with backing)	Any F-No. 1 or 5 with backing
Any F-No. 5 (without backing)	Any F-No. 1 with backing and any F-No. 5 with or without backing
Any F-No. 6	Any F-No. 6
Any F-No. 12	Any F-No. 12 (2)
Any F-No. 13	Any F-No. 13 (2)
Any F-No. 21 thru F-No. 24	Any F-No. 21 through F-No. 24
Any F-No. 26	Any F-No. 26 (2)
Any F-No. 31, 32, 33, 36, or 37	Only the same F-Number that was used during the qualification.
Any F-No. 34 or F-No. 41 thru F-No. 45	F-No. 34 and any F-No. 41 thru F-No. 45
Any F-No. 48	Any F-No. 48 (2)
Any F-No. 51 thru F-No. 54	Any F-No. 51 thru F-No. 54
Any F-No. 55	Any F-No. 55 (2)
Any F-No. 61	Any F-No. 61
Any F-No. 81	Any F-No. 81 (2)
Any F-No. 91	Any F-No. 91 (2)

Note:
(1) Performance qualification tests using a filler metal not listed in Appendix B shall qualify only for that filler metal.
(2) Each filler metal in this F-Number group will require individual qualification.
(3) F-Number filler metal alloys are as follows:

F-No. 1 through F-No. 13 - Steel and Steel Alloys
F-No. 2X - Aluminum and Aluminum-Base Alloys
F-No. 3X - Copper and Copper-Base Alloys
F-No. 4X - Nickel and Nickel-Base Alloys
F-No. 5X - Titanium and Titanium-Base Alloys
F-No. 6X - Zirconium and Zirconium-Base Alloys
F-No. 81 - Cobalt and Cobalt-Base Alloys
F-No. 91 - Magnesium and Magnesium-Base Alloys

6.4 QUALIFICATION BY WORKMANSHIP TEST

Under special conditions, where it is determined that the standard tests may not be fully applicable or do not accommodate the actual hardware requirements, the welder may be qualified by a workmanship test (sometimes referred to as “Production Assembly Mockup”) in lieu of the standard test weld requirements of Section 6.2. This method of qualification must be approved by the responsible Materials & Processes (M&P) organization and shall only apply to welding activities for flight or non flight structural hardware. Welding of non flight pressurized hardware shall be performed only by welders qualified by standard testing.

6.4.1 Workmanship Test Weldments for Non Flight Structural (NFS) Hardware

Performance qualification by workmanship test requires completion of one or more workmanship weldments in accordance with a qualified WPS, representing a typical production configuration(s) and conditions. The workmanship weldment may be an actual production weld in lieu of a test sample representative of the production hardware.

6.4.1.1 Qualification Limitations for NFS Hardware Workmanship Tests

When workmanship qualification testing is performed, the maximum qualification range allowed shall be limited to the condition ranges (i.e., essential variables) allowed by the WPS used to make the test weld. However, the responsible M&P organization shall have the authority to further limit any or all of these condition ranges as determined necessary, to ensure the quality of the manually applied welds.

6.4.1.2 Workmanship Test Examination and Testing for NFS Hardware

At a minimum, workmanship test weldments shall be accepted or rejected based primarily on the visual examination criteria given in section 6.7. As deemed necessary and appropriate by the M&P organization, additional testing (e.g., NDE, metallography, destructive testing, proof testing, etc.) may be specified for the test weldment to validate the soundness and integrity of the deposited welds.

6.4.1.3 Failure of Workmanship Weldment for NFS Hardware

If the performance test is made on a given production weld and it is deemed rejectable during examination, this weld shall be treated according to the applicable process specification requirements for weld repairs. No further welding shall be permitted on the production hardware and further performance testing shall be administered only on mock test samples per 6.4.1 or standard testing per 6.2. All other retesting requirements of 6.5 shall also apply.

6.4.2 Workmanship Test Weldments for Flight Hardware

Performance qualification by workmanship test requires completion of one or more workmanship weldments in accordance with a qualified WPS, representing a typical production configuration(s) and conditions. The workmanship weldment may be an actual production weld in lieu of a test sample representative of the production hardware.

6.4.2.1 Qualification Limitations for Flight Hardware Workmanship Tests

When workmanship qualification testing is performed, the qualification range qualified for production welding shall be limited to the welding conditions of the test weld with regard to process, base metal thickness, specific filler metal, position, weld type and joint configuration employed during the welding of the test weld, and any other welding condition or parameter identified by the M&P organization.

6.4.2.2 Workmanship Test Examination and Testing for Flight Hardware

At a minimum, workmanship test weldments shall be accepted or rejected based on the results of all examinations and testing that duplicate that specified for the production hardware, and at the sames classes of quality as specified for the production welds. As deemed necessary and appropriate by the M&P organization, additional testing (e.g., NDE, metallography, destructive testing, proof testing, etc.) may be specified for the test weldment to validate the soundness and integrity of the deposited welds.

6.4.2.3 Failure of Workmanship Weldment for Flight Hardware

If the performance test is made on a given production weld and it is deemed rejectable during examination, this weld shall be treated according to the applicable process specification requirements for weld repairs. No further welding shall be permitted on the production hardware and further performance testing shall be administered only on mock test samples per 6.4.1 or standard testing per 6.2. All other retesting requirements of 6.5 shall also apply.

6.5 RETESTS

A welder who fails any performance test may be retested under the following conditions described below.

6.5.1 Immediate Retest Upon Test Failure

When the qualification coupon has failed the visual examination, mechanical testing, or radiographic examination, an immediate retest shall be allowed. When an immediate retest is made, the welder shall make two (2) consecutive test coupons for each failed test, both of which shall pass all of the prescribed visual inspection requirements. The qualifier shall then select one (1) of the successful test coupons (for each specific test) for mechanical or radiographic testing. Retesting shall be allowed only once. If a welder fails the retest, further training and practice shall be required prior to attempting another test.

6.5.2 Retest Following Further Training

When the welder has had further training and practice, a retest consisting of all the original test requirements shall be permitted. If welder training is considered necessary it shall be conducted in accordance with TI-0000-04 or a vendor generated training plan.

6.6 QUALIFICATION DURATION

The performance qualification of a welder shall remain in effect indefinitely unless one of the following conditions occur:

a) When the welder has not welded with a process during a period of six (6) months or more, the welder's qualification for that process shall expire.

b) When there is specific reason to question the welder's ability to make welds that meet the applicable specification, the qualifications which support the welding the welder is doing shall be revoked by the M&P organization, management, or supervision. All other qualifications not questioned shall remain in effect.

6.6.1 Renewal of Qualification

a) Renewal of qualification expired under 6.6(a) above may be made for any process by welding a single test coupon of either plate or pipe, of any material, thickness or diameter, in any position, and testing that coupon in accordance with Section 6.2.1 or the original test requirements for that qualification. A successful test renews the welder's previous qualifications for that process.

b) Welders whose qualification have been revoked under 6.6(b) above shall requalify to the same test conditions as administered for the original qualification. Qualification efforts shall utilize the appropriate process, test coupon, position, and all other essential variables employed with the qualification that was revoked and test that coupon in accordance with Section 6.2.1. A successful test restores the qualification.

c) Following an interruption to employment, welders rehired to the same organization within 6 months from the last verification of a certification being current with that employer, shall not be required to recertify at the discretion of the qualifier. If it is determined that the welder's skill in a given process has deteriorated due to the interruption in employment, then at a minimum, the welder shall be required to test per 6.6.1 a) above.

6.7 EXAMINATIONS AND TESTS

All visual inspections of welded test coupons shall be performed by an American Welding Society (AWS) Certified Welding Inspector (CWI) qualified in accordance with AWS QC-1. The CWI certification must be current.

6.7.1 Visual Examination of Groove Welds

All test coupons shall be examined in the "as welded" condition with the weld reinforcement left substantially intact unless otherwise directed by the qualifier. However, at the discretion of the qualifier, surface dressing such as minor grinding, sanding, wire brushing, and/or light filing shall be allowed to prepare the weld for inspection.

For plate coupons, all surfaces (except areas designated "discard" or "drop off") shall be examined visually before the cutting of bend specimens or prior to radiographic examination. Tube/pipe coupons shall be visually examined over the entire circumference, inside and outside before the cutting of bend specimens or prior to radiographic examination. The acceptance criteria is as follows and "T" shall mean "base metal thickness":

a) Cracks are unacceptable.
b) Underfill (caused by welding or mechanical means) is unacceptable.

c) Complete fusion and joint penetration is required.
d) Overlap is unacceptable.
e) Mismatch allowed in T ≤1/16" shall not exceed 0.2T. Where T >1/16" mismatch shall not exceed 0.1T or 0.10", whichever is less.
f) Weld reinforcement shall be substantially smooth and shall transition into the base metal gradually so as to form a considerably "low stress" surface condition. Weld reinforcement allowed for the root and face for T ≤1/16" shall not exceed 0.02" + T or 0.05", whichever is less, and for T >1/16" shall not exceed 0.8T or 1/8", whichever is less.
g) Undercut (caused by welding or mechanical means) shall not be greater than 0.1T deep or 1/32", whichever is less.
h) For T ≤1/16" there shall be no voids or inclusions >1/32" or 0.6T in any dimension, whichever is less. For T >1/16" there shall be no voids or inclusions >3/32" or 0.4T in any dimension, whichever is less. If 2 or more voids/inclusions are separated by a distance ≤ the diameter of the larger void, the cluster shall be counted as one void and measured and evaluated accordingly to the criteria above.
i) Arc strikes are unacceptable and shall be removed.

6.7.2 Visual Examination of Fillet Welds

For plate coupons all surfaces (except areas designated "discard") shall be examined visually before the cutting of fracture and macro examination specimens. Pipe-to-pipe and pipe-to-plate coupons shall be visually examined over the entire circumference before the cutting of fracture and macro examination specimens. The acceptance criteria is as follows and and "T" shall mean "base metal thickness":

a) Cracks are unacceptable.
b) Overlap is unacceptable.
c) Fillet weld leg size shall be equal to the thickness of the thinner component being joined unless otherwise specified by the qualifier. Maximum leg size shall not exceed 0.2T or 3/16" greater than the minimum required, whichever is the lesser, unless otherwise specified by the qualifier.
d) Fillet welds shall have approximately equal legs. If the legs of the weld are measurably different, the leg size ratio shall be no greater than 1.5 at any location.
e) Weld reinforcement shall be substantially smooth and shall transition into the base metal gradually so as to form a considerably "low stress" surface condition. Welds may be slightly concave, convex, or flat. Concavity and convexity shall not exceed 10% of the average leg size or 1/16", whichever is the lesser, at any location.
f) Undercut (caused by welding or mechanical means) shall not be greater than 0.1T deep or a maximum of 1/32", whichever is less.
g) For T ≤1/16" there shall be no voids or inclusions >1/32" or 0.6T in any dimension, whichever is less. For T >1/16" there shall be no voids or inclusions >3/32" or 0.4T in any dimension, whichever is less. If 2 or more voids/inclusions are separated by a distance ≤ the diameter of the larger void, the cluster shall be counted as one void and measured and evaluated accordingly to the criteria above.
h) Arc strikes are unacceptable and shall be removed.

6.7.3 Radiographic Examination

Radiographic examination is intended to evaluate the internal quality of a weld deposit therefore the criteria stated herein is intended to be applied to the same. However, where a weld test coupon(s) cannot be adequately evaluated/inspected by visual examination on all external surfaces (e.g., small diameter tubes/pipe), the applicable criteria stated above in 6.7.1 shall also apply to the radiographic film interpretation.

When a welder is qualified by radiographic examination, as permitted by Section 6.2.1, the minimum length of coupon(s) to be examined shall be six (6) inches and shall include the entire weld for plate (less designated discard sections) and the entire weld circumference for pipes. For small diameter tube/pipe, multiple coupons may be required, but the number need not exceed four (4) consecutively made coupons. The acceptance criteria is as follows and "T" shall mean "base metal thickness":

a) Cracks are unacceptable.
b) Lack of fusion is unacceptable.
c) For T $\leq$1/16" there shall be no indications, voids, or inclusions $>$1/32" or 0.6T in any dimension, whichever is less. For T $>$1/16" there shall be no indications, voids, or inclusions $>$3/32" or 0.4T in any dimension, whichever is less. If 2 or more voids/inclusions are separated by a distance $\leq$ the diameter of the larger void, the cluster shall be counted as one void and measured and evaluated accordingly to the criteria above.

6.7.4 Guided Bend Testing

When a welder is qualified by guided bend testing, test specimens shall be prepared by cutting the test plate or tube/pipe to form specimens of approximately rectangular cross section. The cut surfaces shall designate the sides of the specimen. The other two surfaces shall be called the face and the root surfaces. For plate coupons the face shall be designated as the side that the weld the weld was made from (torch side) for single sided welds or the side of the weld that the first weld pass(es) was made from for double sided welds. For tube/pipe coupons, the outside surface of the tube/pipe is typically the torch side. In any case, equal numbers of specimens shall be tested from each side of the test coupon.

6.7.4.1 Test Specimen Removal

The location of specimen removal shall be in substantial accordance with the following figures located in Appendix A.

For plate test coupons, the following shall apply:

a) Transverse face and root, or side bends in accordance with Figure A8.
b) Longitudinal face and root bends in accordance with Figure A9.

For tubular product test coupons, only transverse bends are used and the following shall apply:

a) Face and root bend specimens removed from tube/pipe with a wall thickness of up to 0.750" in accordance with Figure A10.
b) Side bend specimens removed from tube/pipe with a wall thickness of 0.750" and over and alternate from 0.375" but less than 0.750" wall thickness in accordance with Figure A11.

c) In the situation where a square (box) tubular product is used for the test weld, specimens shall be removed from the test weldment in substantial accordance with the applicable figure found in Chapter 3 of AWS B2.1.

For tubular products with a diameter equal to or less than 1-3/8" O.D., the bend specimens may be obtained by cutting the tube/pipe into quarter sections. These quarter sections specimens are not required to have one surface machined flat.

6.7.4.2 Preparation of Test Specimens

The size and preparation of guided bend specimens (plate or tube/pipe) shall be in substantial accordance with the following figures in Appendix A.

a) Side bend specimens in accordance with Figure A12.
b) Transverse face and root bend specimens in accordance with Figure A13.
c) Longitudinal face and root bend specimens in accordance with Figure A14.

6.7.4.3 Test Jigs

Guided bend specimens shall be bent in test jigs that are in substantial accordance with the following figures in Appendix A. Bend radii and other test jig dimension shall be in accordance with Table A in Appendix A.

a) Guided bend test jig, in accordance with Figure A15. When using the guided bend jig, the side of the specimen turned toward the gap in the jig shall be the face for face bend specimens, the root for root bend specimens, and the side with the greater defects, if any, for the side bend specimens. The specimen shall be forced into the die by applying a load on the plunger until the curvature of the specimen is such that a 0.125" diameter wire cannot be inserted between the specimen and the die.

b) Guided bend roller test jig (bottom ejection), in accordance with Figure A16. When using the guided bend roller jig, the side of the specimen turned toward the gap in the jig shall be the face for face bend specimens, the root for root bend specimens, and the side with the greater defects, if any, for the side bend specimens. The specimen shall be forced into the die by applying a load on the plunger until the specimen is bottom ejected.

c) Wrap around jig, in accordance with Figure A17. When using the wrap around jig, the side of the specimen turned toward the roller shall be the face for face bend specimens, the root for root bend specimens, and the side with the greater defects, if any, for the side bend specimens.

6.7.4.4 Acceptance Criteria

The acceptance criteria for guided bend test shall be as follows:

a) The weld and heat affected zone of a transverse specimen shall be completely in the bent portion of the specimen after testing.
b) There shall be no open defects in the weld or heat affected zone $>$1/8", measured in any direction on the convex surface of the specimen after bending.
c) Open defects occurring on the corners of the specimen during testing shall not be considered unless there is definite evidence that they result from lack of fusion, slag inclusions, or other internal defects.

6.7.5 Fracture Test

The stem of the plate specimen 4 inch center section in accordance with Appendix A, Figure A18 or the stem of one of the pipe quarters in accordance with Figure A19 or A20, as applicable, shall be loaded laterally in such a way that the root of the weld is in tension. The load shall be steadily increased until the specimen fractures or bends flat upon itself. If the specimen does not fracture, it shall be considered acceptable. If the specimen fractures, the acceptance criteria is as follows:

a) The fractured surface shall show no evidence cracks or incomplete root fusion.
b) The sum of the lengths of inclusions and porosity visible on the fractured surface shall not exceed 3/8” in plate specimens or 10% of the length of the quarter section of tube/pipe.

6.7.6 Macro Examination

The cut end of one of the end plate sections in accordance with Appendix A, Figure A18 or the cut end of one of the tube/pipe quarters in accordance with Figure A19 or A20, as applicable, shall be smoothed and etched with a suitable etchant to give a clear definition of the weld metal and heat affected zone and then examined. The acceptance criteria is as follows:

a) Complete fusion is required.
b) There shall be no cracks.

7.0 DEVIATIONS AND WAIVERS

Any deviations or waivers regarding the use of this process specification shall be requested in writing. This request shall be directed to the NASA/JSC M&P organization with the appropriate justification and rationale. A written response will be provided upon such a request.

Appendix A

AMS-STD 1595 QUALIFICATION TEST RECORD

Name _____ Id. _____ SS No. _____

Joint welding procedure _____ Welder [ ] Welding operator [ ]

TEST WELD

Base metal description _____ Group No. _____

Welding process _____ Single weld [ ] Double weld [ ]

Current AC [ ] DC [ ] Backing Yes [ ] No [ ]

Vertical Down [ ] Up [ ] Penetration Complete [ ] Partial [ ]

	Position					Dimension, inch
Sheet groove	1G [ ]	2G [ ]	3G [ ]	4G [ ]	4G-I [ ]	t _____
Tube groove	1G [ ]	2G [ ]	5G [ ]	6G [ ]		O.D. _____ t _____
Sheet fillet	1F [ ]	2F [ ]	3F [ ]	4F [ ]		t _____
Tube fillet	1F [ ]	2F [ ]	2FR [ ]	4F [ ]	5F [ ]	O.D. _____ t _____

TEST RESULTS

Visual		Pass [ ]	Fail [ ]
Radiographic	NA [ ]	Pass [ ]	Fail [ ]
Bend	NA [ ]	Pass [ ]	Fail [ ]
Metallographic	NA [ ]	Pass [ ]	Fail [ ]

QUALIFIED

Base Metal Group No. _____ Single weld [ ] Double weld [ ]

Current AC [ ] DC [ ] Backing Yes [ ] No [ ]

Vertical Down [ ] Up [ ] Penetration Complete [ ] Partial [ ]

	Position					t, inch		O.D., inch	
						Min.	Max.	Min.	Max.
Sheet groove	Flat [ ]	Hori [ ]	Vert [ ]	Over [ ]	ALL [ ]				
Tube groove	Flat [ ]	Hori [ ]	Vert [ ]	Over [ ]	ALL [ ]				
Sheet fillet	Flat [ ]	Hori [ ]	Vert [ ]	Over [ ]	ALL [ ]				
Tube fillet	Flat [ ]	Hori [ ]	Vert [ ]	Over [ ]	ALL [ ]				

The above named individual is qualified in accordance with PRC-0008 which meets the requirements of AMS-STD-1595 within the above limits for the welding process used for this test weld.

Date of test weld _____ Qualifier _____

Figure A1

Verify correct version before use.

Appendix A

AWS B2.1 PERFORMANCE QUALIFICATION TEST RECORD

Name _____ Identification _____ Welder ( ) Operator ( )

Social security number _____ Qualified to WPS no. _____

Process(es) _____ Manual ( ) Semi-Automatic ( ) Automatic ( ) Machine ( )

Test base metal specifications _____ To _____

Material number _____ To _____

Fuel gas (OFW) _____

AWS filler metal classification _____ F no. _____

Backing : Yes ( ) No ( ) Double ( ) or Single side ( )

Current : Ac ( ) DC ( ) Short-circuiting arc (GMAW) Yes ( ) No ( )

Consumable insert : Yes ( ) No ( )

Root shielding : Yes ( ) No ( )

TEST WELDMENT	**POSITION TESTED**				**WELDMENT THICKNESS (T)**
GROOVE :					
Pipe	1G ( )	2G ( )	5G ( )	6G ( )	Diameter(s) _____ (T) _____
Plate	1G ( )	2G ( )	3G ( )	4G ( ) 4G-I ( )	(T) _____
Rebar	1G ( )	2G ( )	3G ( )	4G ( )	Bar size _____ Butt ( ) Spliced butt ( )
FILLET :					
Pipe	1F ( )	2F ( )	3F ( )	4F ( ) 5F ( )	Diameter _____ (T) _____
Plate	1F ( )	2F ( )	2FR ( )	4F ( )	(T) _____
Other (describe) _____					

Test results :			Remarks
Visual test results	N/A ( )	Pass ( )	Fail ( )
Bend test results	N/A ( )	Pass ( )	Fail ( )
Macro test results	N/A ( )	Pass ( )	Fail ( )
Tension test	N/A ( )	Pass ( )	Fail ( )
Radiographic test results	N/A ( )	Pass ( )	Fail ( )
Penetrant test	N/A ( )	Pass ( )	Fail ( )

QUALIFIED FOR :

PROCESSES

GROOVE :						**THICKNESS**
Pipe	Flat ( )	Hori ( )	Vert ( )	Over ( )	ALL ( )	(T) Min _____ Max _____ Dia _____
Plate	Flat ( )	Hori ( )	Vert ( )	Over ( )	ALL ( )	(T) Min _____ Max _____
Rebar	Flat ( )	Hori ( )	Vert ( )	Over ( )	ALL ( )	Bar size Min _____ Max _____
FILLET :						
Pipe	Flat ( )	Hori ( )	Vert ( )	Over ( )	ALL ( )	(T) Min _____ Max _____
Plate	Flat ( )	Hori ( )	Vert ( )	Over ( )	ALL ( )	(T) Min _____ Max _____
Rebar	Flat ( )	Hori ( )	Vert ( )	Over ( )	ALL ( )	Bar size Min _____ Max _____

Weld cladding ( ) Position(s) _____ T Min _____ Min _____ Clad Min _____

Consumable insert ( ) Backing type ( )

Vertical Up ( ) Down ( )

Single side ( ) Double side ( ) No backing ( )

Short-circuiting arc ( ) Spray arc ( ) Pulsed arc ( )

Reinforcing bar - butt ( ) or Spliced butt ( )

The aboved named person is qualified in accordance with PRC-0008 which meets the requirements of AWS B2.1 within the above limits for the welding process used for this test weld.

Date tested _____ Qualifier _____

Figure A2

Verify correct version before use.

Appendix A

ASME SEC IX WELDER/WELDING OPERATOR PERFORMANCE QUALIFICATIONS

Welder's name _____ Clock number _____ Stamp no. _____

Welding process(es) used _____ Type _____

Identification of WPS followed by welder during welding of test coupon _____

Base material(s) welded _____ Thickness _____

Manual or Semiautomatic Variables for Each Process (QW-350)	**Actual Values**	**Range Qualified**
Backing (metal, weld metal, welded from both sides, flux, etc.) (QW-402)		
ASME P-No. _____ to ASME P-No. (QW-403)		
( ) Plate ( ) Pipe (enter diameter if pipe)		
Filler metal specification (SFA) : _____ Classification (QW-404)		
Filler metal F-No.		
Consumable insert for GTAW or PAW		
Weld deposit thickness for each welding process		
Welding position (1G, 5G, etc.) (QW-405)		
Progression (uphill/downhill)		
Backing gas for GTAW, PAW, or GMAW; fuel gas for OFW (QW-408)		
GMAW transfer mode (QW-409)		
GTAW welding current type/polarity		

Machine Welding Variables for the Process Used (QW-360)	**Actual Values**	**Range Qualified**
Direct/remote visual control		
Automatic voltage control (GTAW)		
Automatic joint tracking		
Welding position (1G, 5G, etc.)		
Consumable insert		
Backing (metal, weld metal, welded from both sides, flux, etc.)		

Guided Bend Test Results

Guided Bend Tests Type ( ) QW-462.2 (Side) Results ( ) QW-462.3(a) (Trans. R & F Type) ( ) QW-462.3(b) (Long. R & F) Results

Visual examination results (QW-302.4) _____

Radiographic test results (QW-304 and QW-305) _____

(For alternative qualification of groove welds by radiography)

Fillet Weld - Fracture test _____ Length and percent of defects _____ in.

Macro test fusion _____ Fillet leg size _____ in. x _____ in. Concavity/Convexity _____ in.

Welding test conducted by _____

Mechanical tests conducted by _____ Laboratory test no. _____

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of PRC-0008 which meets or exceeds the requirements of Section IX of the ASME Code.

Date _____ Organization _____

By _____

Figure A3

Appendix A

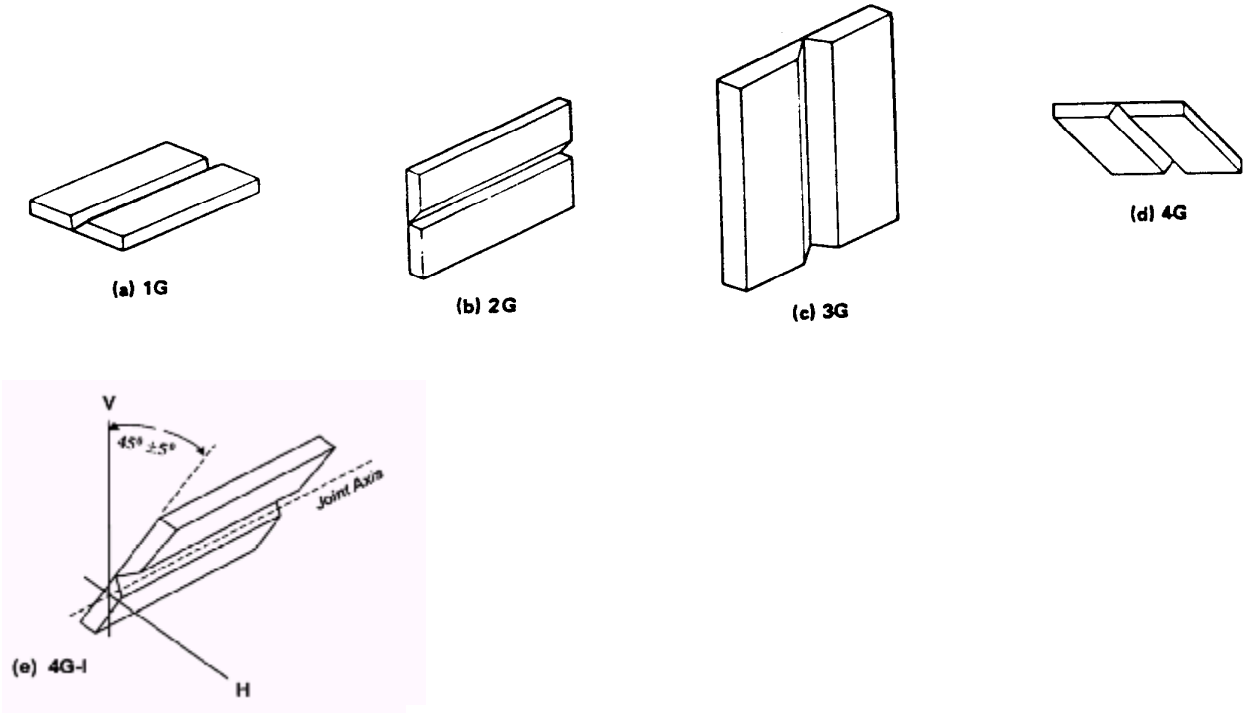


Figure A4 - Groove Welds in Plate, Test Positions

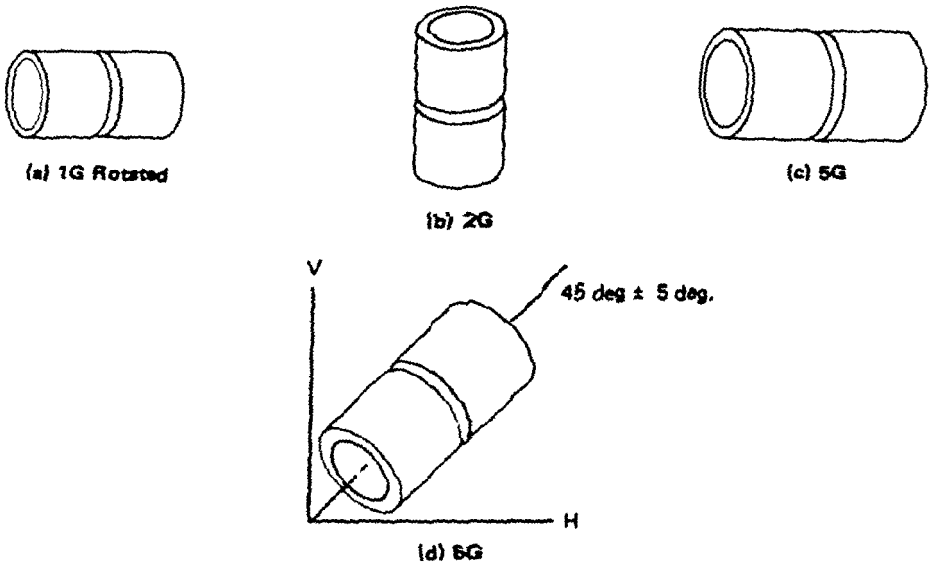


Figure A5 - Groove Welds in Pipe, Test Positions

Appendix A

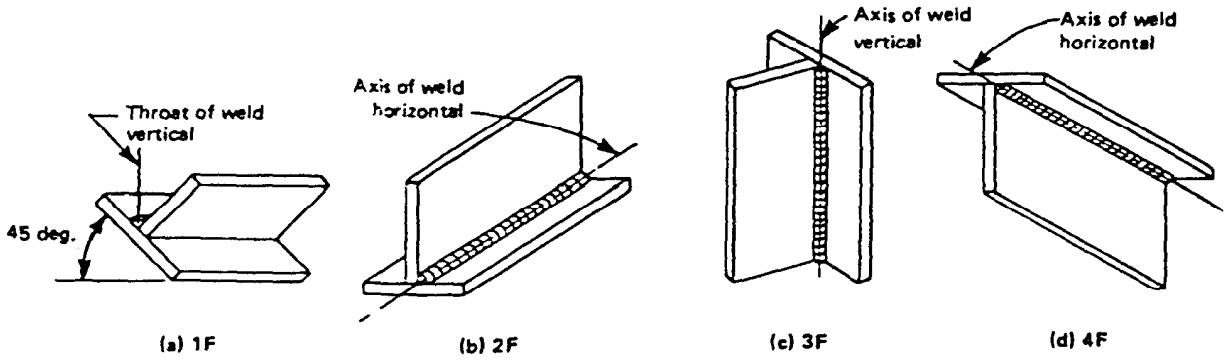


Figure A6 - Fillet Welds in Plate, Test Positions

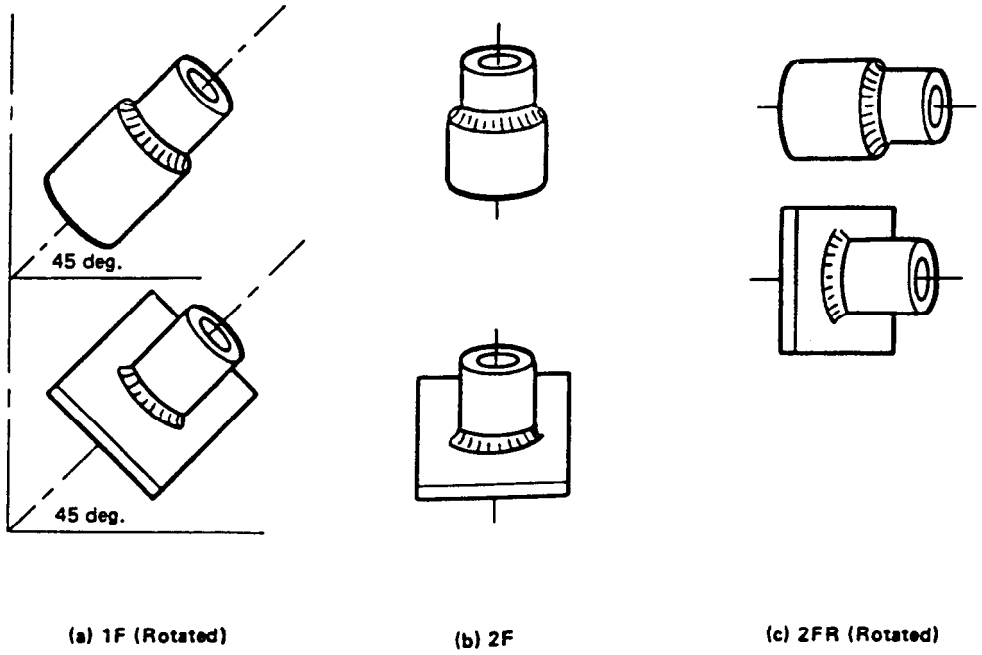


Figure A7 - Fillet Welds in Pipe, Test Positions

Appendix A

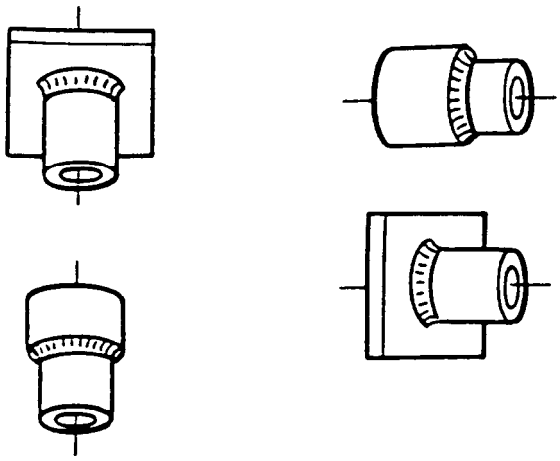


Figure A7 (continued) - Fillet Welds in Pipe, Test Positions

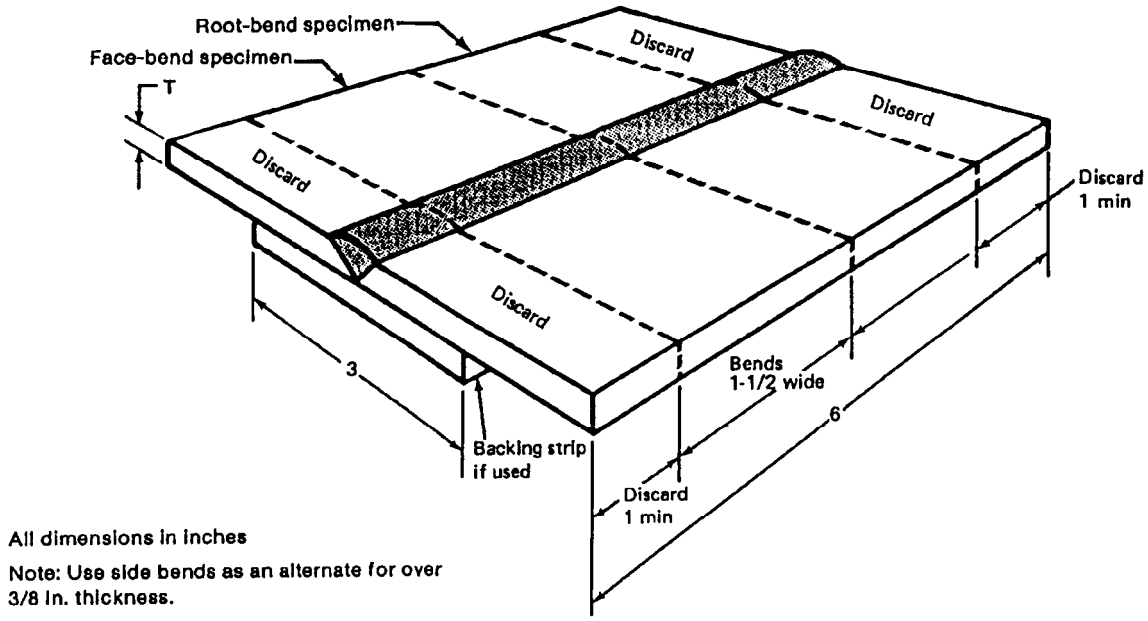


Figure A8 - Standard Plate Transverse Bend Test Weldments

Appendix A

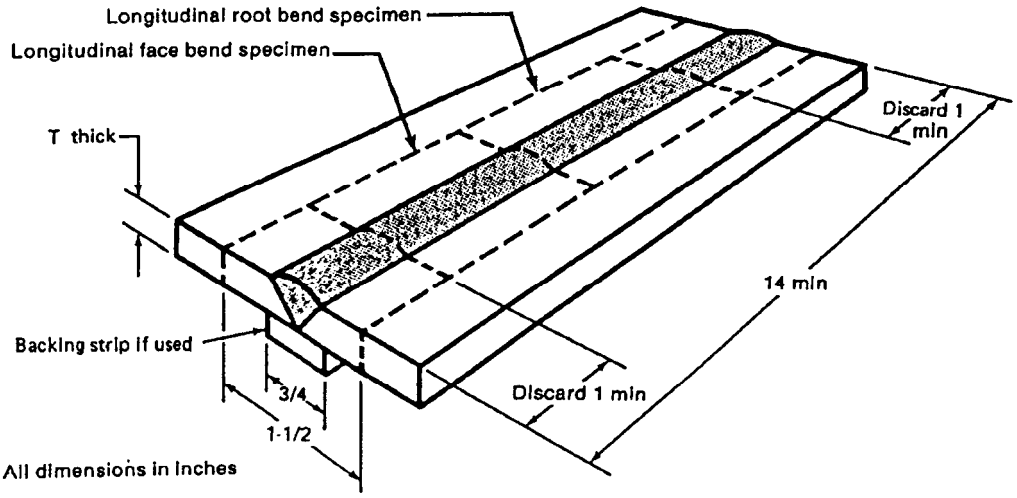
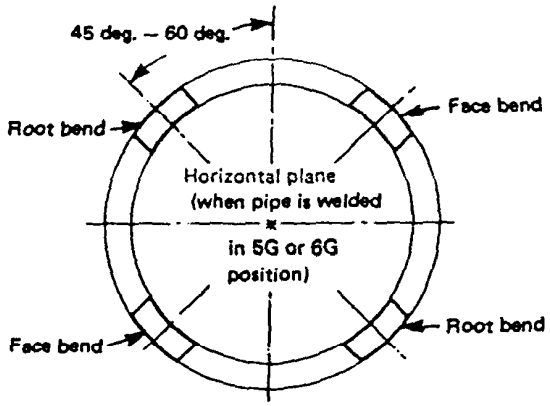
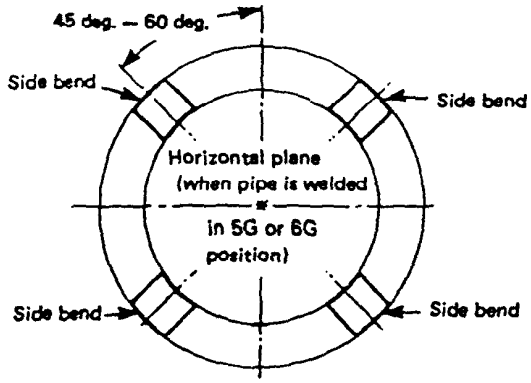


Figure A9 - Alternate Plate Test Weldment, Longitudinal Bends



Pipes — 1/16 Up to 3/4 in. Thickness

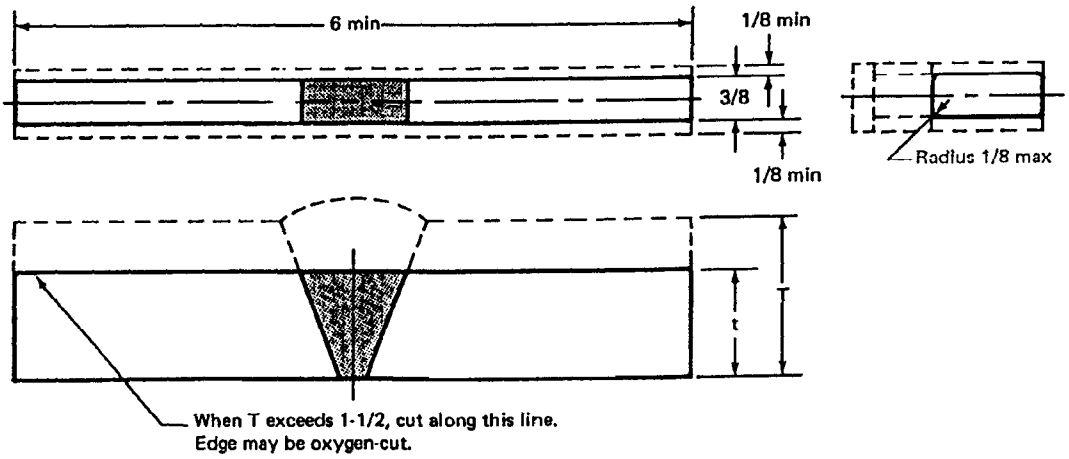
Figure A10 - Face and Root Bends



Pipes — 3/4 in. and Over Thickness and Alternate From 3/8 in. but Less Than 3/4 in. Thickness

Figure A11 - Side Bends

Appendix A



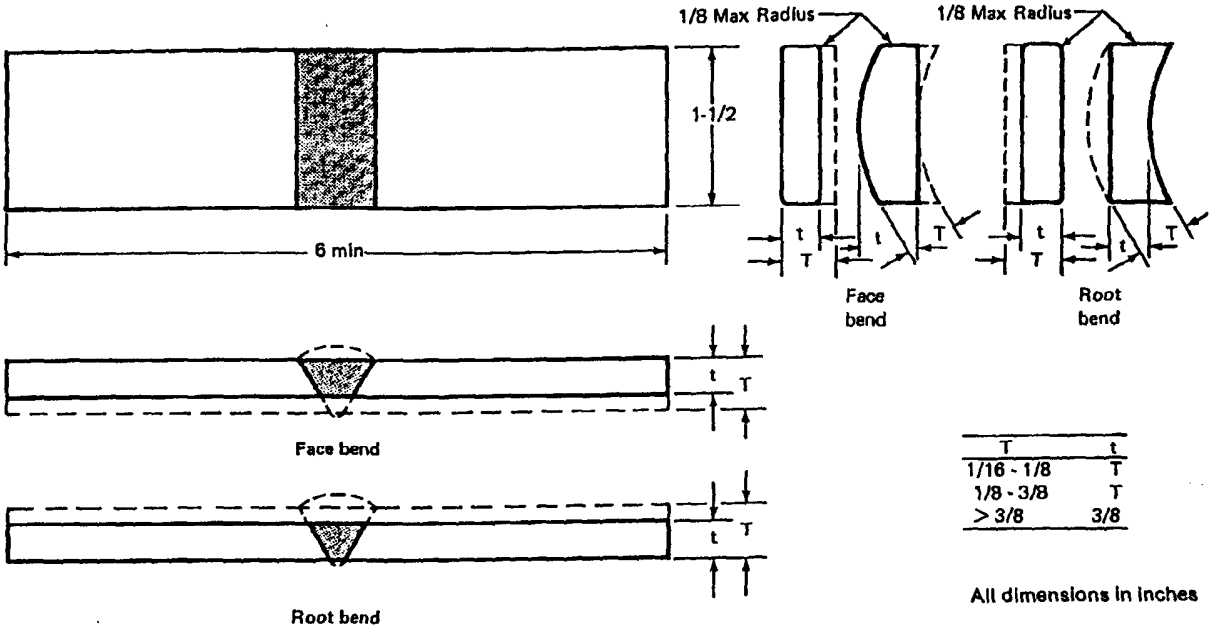
T, in.	t, in.
3/8 to 1-1/2	T
>1-1/2	See Note 2

All dimensions in inches

Notes:

1. A longer specimen length may be necessary when using a wraparound-type bending fixture or when testing steel with a yield point of 90 ksi or more.
2. For plates over 1-1/2 in. thick, cut the specimen into approximately equal strips with t between 3/4 and 1-1/2 in. and test each strip.

Figure A12 - Transverse Side Bend Specimens

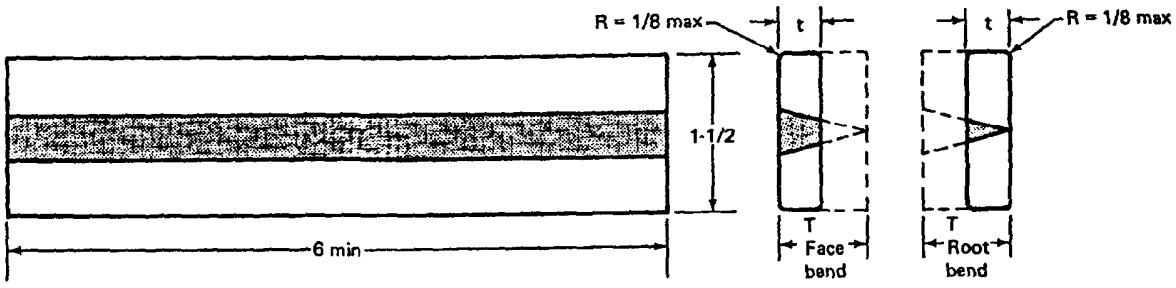


T	t
1/16 - 1/8	T
1/8 - 3/8	T
> 3/8	3/8

All dimensions in inches

Figure A13 - Transverse Face and Root Bend Specimens

Appendix A



T, in.	t, in. P-No. 23, F-No. 23, and P-No. 35	t, in. All Other Metals
1/16-1/8	T	T
1/8-3/8	1/8	T
>3/8	1/8	3/8

All dimensions in inches

Note: A longer specimen length may be necessary when using a wraparound type bending fixure or when testing steel with a yield strength of 90 ksi or more.

Figure A14 - Longitudinal Face and Root Bend Specimens

Appendix A

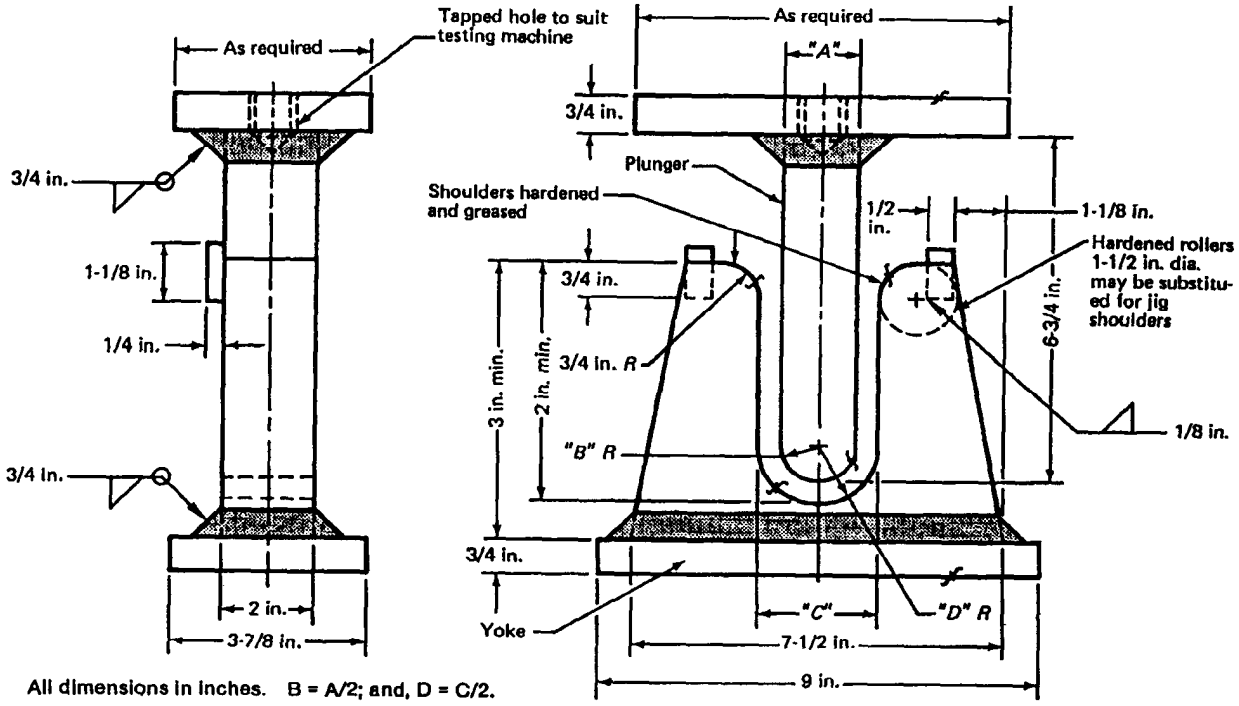


Figure A15 - Guided Bend Test Jig

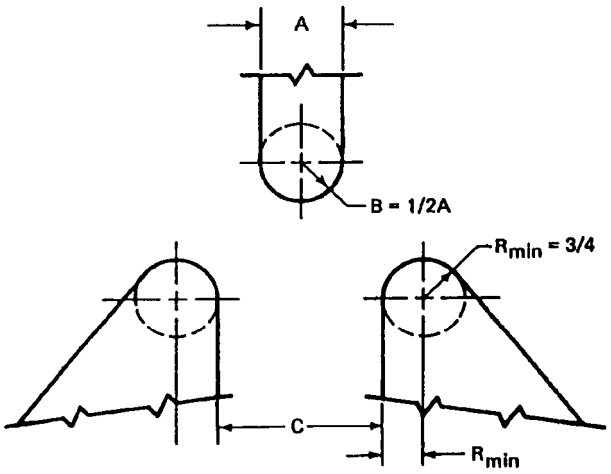


Figure A16 - Guided Bend Roller (Bottom Ejection) Test Jig

Appendix A

Table A - Guided Bend Test Jig Dimensions

Base Metal	Thickness of Specimen	"A" (T or inches)	"C" (T or inches)
M-No. 2X, welded with F-No. 23; M-No. 23, as welded; M-No. 35; Any M-No. welded with F-No. 36	1/8"	2-1/16"	2- 3/8"
	Less than 1/8"	16-1/2 T	18-1/2 T + 1/16"
M-No. 11; M-No. 25	3/8"	2-1/2"	3- 3/8"
	Less than 3/8"	6-2/3 T	8-2/3 T + 1/8"
M-No. 51	3/8"	3"	3-7/8"
	Less than 3/8"	8 T	10 T + 1/8"
M-No. 55	All	20 T	22 T + 1/8"
M-No. 52; M-No. 53; M-No. 61; M-No. 62	3/8"	3-3/4"	4-5/8"
	Less than 3/8"	10 T	12 T + 1/8"
All other M-Numbers with greater than or equal to 20% elongation	3/8"	1-1/2"	2- 3/8"
	Less than 3/8"	4 T	6 T + 1/8"
All other M-Numbers with less than 20% elongation	(see note 1)	37-7/8 T max.	34-7/8 T + 1/16 "

Note 1 - The dimensions of the test jig shall be such as to give the bend specimen a calculated percent outer fiber elongation equal to at least that of the base material joined with the lower minimum elongation as specified in the base material specification.

$$\text{Percent outer fiber elongation } (P_{OFE}) = \frac{100T}{A + T}$$

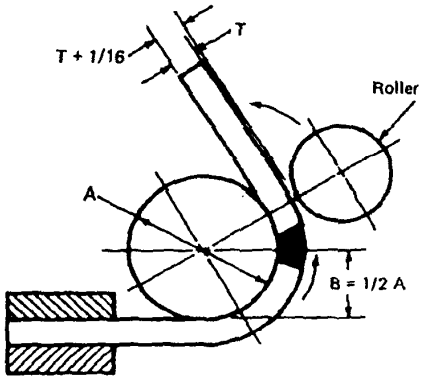
The following formula is provided for calculating the bend specimen thickness:

$$\text{Thickness of specimen} = \frac{A \times \text{percent elongation}}{[\,(100 - (\text{percent elongation})\,]} \quad \text{or,}$$

The following formula is provided for calculating the diameter of the bend mandrel (A):

$$A = \frac{100T}{P_{OFE}} - T$$

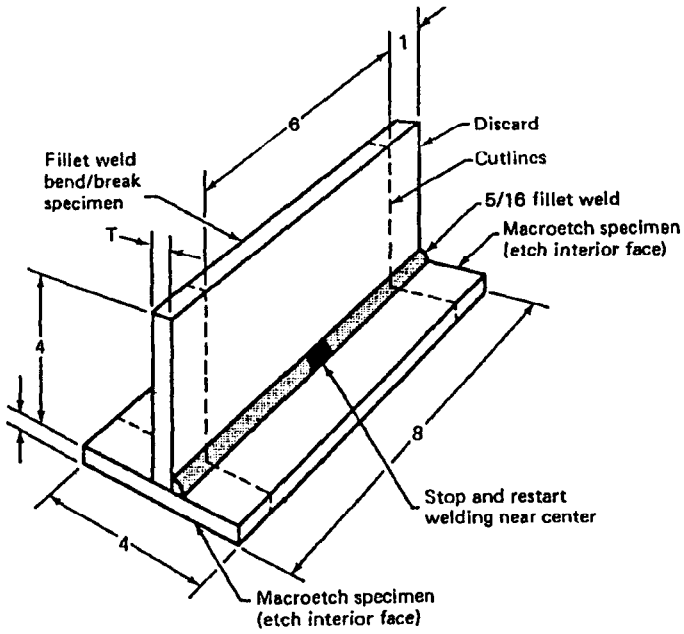
Appendix A



Notes:

1. Dimensions not shown are the option of the designer. The essential consideration is to have adequate rigidity so that the jig parts will not spring.
2. The specimen shall be firmly clamped on one end so that there is no sliding of the specimen during the bending operation.
3. Test specimens shall be removed from the jig when the outer roll has been moved 180 deg. from the starting point.

Figure A17 - Guided Bend (Wrap Around) Test Jig



All dimensions in inches

Note: Plate thickness and dimensions are minimum.

Figure A18 - Standard Fillet Weld Test Weldment - Plate

Appendix A

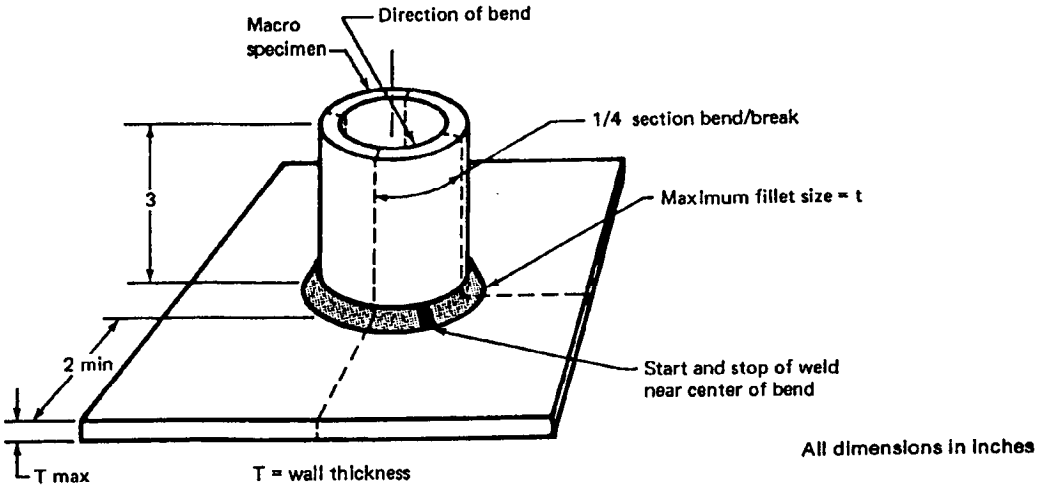


Figure A19 - Standard Fillet Weld Test Weldment, Pipe

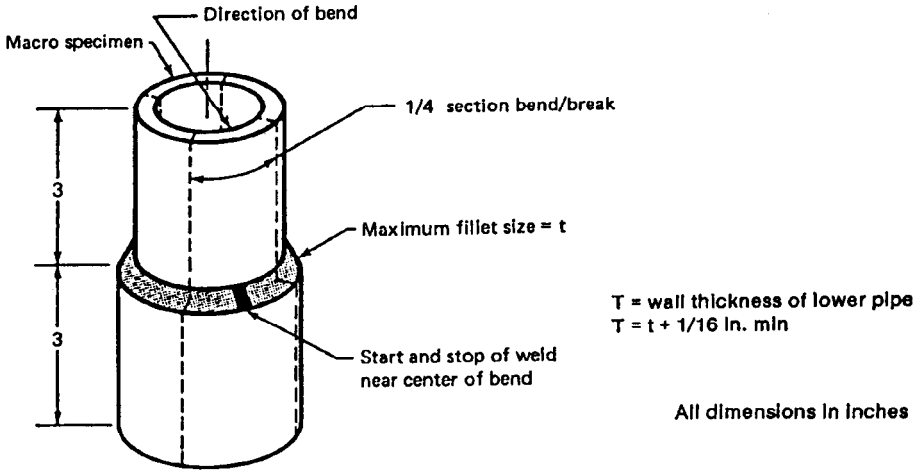


Figure A20 - Alternate Fillet Weld Test Weldment, Pipe

Appendix B

F-Numbers - Grouping of Electrodes and Welding Rods for Qualification

F-No.	ASME & AWS or AMS Specification No.	AWS Classification Number or Other
		Steel and Steel Alloys
1	5.1 & 5.5	EXX20, EXX22, EXX24, EXX27, EXX28
	5.4	EXX25, EXX26
2	5.1 & 5.5	EXX12, EXX13, EXX13-X, EXX14, EXX19
3	5.1 & 5.5	EXX10, EXX10-X, EXX11, EXX-11-X
4	5.1 & 5.5	EXX15, EXX15-X, EXX16, EXX18, EXX48
	5.4, other than austenitic and duplex	EXX15, EXX16, EXX17
5	5.4, austenitic and duplex	EXX15, EXX16, EXX17
6	5.2	RX
	5.9	ERXX
	5.18	ERXXS-X, EXXC-X,EXXC-XX
	5.20	EXXT-X
	5.22	EXXXT-X
	5.28	ERXXS-X, & EXXC-X
	5.29	EXXTX-X
12	AMS 6457	4130 (VM)
	AMS 6458	17-22AS (VM)
	AMS 6461	6130 (VM)
	AMS 6462	6130
	AMS 6463	MAR300
	AMS 6466	502
	AMS 6468	HP-4-20 (VM)

Appendix B

F-Numbers - Grouping of Electrodes and Welding Rods for Qualification

F-No.	ASME & AWS or AMS Specification No.	AWS Classification Number or Other
		Steel and Steel Alloys (continued)
13	AMS 5774	AM350
	AMS 5780	AM355
	AMS 5782	19-9Wmo
	AMS 5784	29-9
	AMS 5812	15-7 Mo
	AMS 5817	Greek Ascoloy
	AMS 5823	Jethete
	AMS 5824	17-7
	AMS 5825	17-4
	AMS 5840	14-8 Mo
		Aluminum and Aluminum-Base Alloys
21	5.10	ER1100
22	5.10	ER5554, ER5356, ER5556, ER5183, ER5654
23	5.10	ER4009, ER4010, ER4043, ER4047, ER4145, ER4643,
24	5.10	R-A356.0, R-SC 51A, R-SG 70A
26	5.10	ER2319
		Copper and Copper-Base Alloys
31	5.6	Ecu
	5.7	ERCu
32	5.6	ECuSi
	5.7	ERCuSi-A
33	5.6	ECuSn-A & ECuSn-C
	5.7	ERCuSn-A

Appendix B

F-Numbers - Grouping of Electrodes and Welding Rods for Qualification

F-No.	ASME & AWS or AMS Specification No.	AWS Classification Number or Other
		Copper and Copper-Base Alloys (continued)
34	5.6	ECuNi
	5.7	ERCuNi
36	5.6	ECuAl-A2 & ECuAl-B
	5.7	ERCuAl-A1, ERCuAl-A2, ERCuAl-A3
37	5.6	ECuNiAl & ECuMnNiAl
	5.7	ERCuNiAl & ERCuMnNiAl
		Nickel and Nickel-Base Alloys
41	5.11	ENi-1
	5.14	ERNi-1
42	5.11	ENiCu-7
	5.14	ERNiCu-7
43	5.11	ENiCrFe-1, ENiCrFe-2, ENiCrFe-3, ENiCrFe-4, ENiCrCoMo-1, ENiCrMo-2, ENiCrMo-3, ENiCrMo-6
	5.14	ERNiCr-3, ERNiCrFe-5, ERNiCrFe-6, ERNiCrCoMo-1, ERNiCrMo-2, ERNiCrMo-3,
44	5.11	ENiMo-1, ENiMo-3, ENiMo-7, ENiCrMo-4, ENiCrMo-5, ENiCrMo-7, ENiCrMo-10
	5.14	ERNiMo-1, ERNiMo-2, ERNiMo-7 (alloy B-2), ERNiCrMo-4, ERNiCrMo-5, ERNiCrMo-7 (alloy B-4), ERNiCrMo-10
45	5.11	ENiCrMo-1, ENiCrMo-9, ENiCrMo-11
	5.14	ERNiCrMo-1, ERFeCr-1, ERNiCrMo-8, ERNiCrMo-9, ERNiCrMo-11
48	AMS 5660	Alloy 901
	AMS 5683	Alloy 42
	AMS 5687	Inconel 600
	AMS 5698	Inconel X-750
	AMS 5778	Inconel 69

Appendix B

F-Numbers - Grouping of Electrodes and Welding Rods for Qualification

F-No.	ASME & AWS or AMS Specification No.	AWS Classification Number or Other
		Nickel and Nickel-Base Alloys (continued)
48	AMS 5800	Rene 41
cont.	AMS 5804	A286
	AMS 5805	A286 (VM)
	AMS 5828	Waspalloy
		Titanium and Titanium Alloys
51	5.16	ERTi-1, ERTi-2, ERTi-3, ERTi-4,
52	5.16	ERTi-7
53	5.16	ERTi-9, ERTi-9ELI
54	5.16	ERTi-12,
55	5.16	ERTi-5, ERTi-5ELI, ERTi-6, ERTi-6ELI
		Zirconium and Zirconium Alloys
61	5.24	ERZr-2, ERZr-3, ERZr-4
		Cobalt and Cobalt Base Alloys
81	AMS 5789	Stellite 31
	AMS 5796	Haynes 25 (L-605)
	AMS 5801	Haynes 188
		Magnesium and Magnesium Base Alloys
91	AMS 4350	AZ-61A
	AMS 4395	AZ-92A
	AMS 4396	EZ-33A
	AMS 4418	QE-22A

Appendix C

M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Steel and Steel Alloys	
1	J02502	WCA	ASTM- A216
	J02503	WCC	ASTM- A216
	J03002	WCB	ASTM- A216
	K00040	--	ASTM- A620
	K01200	A	ASTM- A178, A179
	K01201	--	ASTM- A179, A192, A226
	K01501	A	ASTM- A414
	K01700	All types, grades, & classes	ASTM- A285
	K01800	All types, grades, & classes	ASTM- A516
	K01807	A2	ASTM- A214, A556, A557
	K02001	All types, grades, & classes	ASTM- A284, A515
	K02100	All types, grades, & classes	ASTM- A516
	K02104	All types, grades, & classes	ASTM- A524
	K02200	All types, grades, & classes	ASTM- A285
	K02201	B	ASTM- A414
	K02202	All types, grades, & classes	ASTM- A442
	K02203	B	ASTM- A662
	K02401	All types, grades, & classes	ASTM- A283, A284, A515
	K02402	All types, grades, & classes	ASTM- A442
	K02403	All types, grades, & classes	ASTM- A516
	K02501	All types, grades, & classes	ASTM- A106, A369
	K02503	C	ASTM- A414
	K02504	All types, grades, & classes	ASTM- A53, A523
	K02505	All types, grades, & classes	ASTM- A414
	K02506	Carbon Steel	ASTM- A727
	K02700	All types, grades, & classes	ASTM- A516
	K02704	E	ASTM- A414
	K02800	All types, grades, & classes	ASTM- A515
	K02801	All types, grades, & classes	ASTM- A285
	K02803	All types, grades, & classes	ASTM- A299
	K03002	Type 1	ASTM- A372
	K03003	All types, grades, & classes	ASTM- A139
	K03005	All types, grades, & classes	ASTM- A53, A523
	K03006	All types, grades, & classes	ASTM- A106, A234, A333, A334, A369, A556
	K03007	B2	ASTM- A557
	K03008	1	ASTM- A333, A334
	K03009	LF1	ASTM- A350
	K03011	LF2	ASTM- A350
	K03017	Cl. 4	ASTM- A266
	K03101	All types, grades, & classes	ASTM- A515
	K03102	F	ASTM- A414

Appendix C

M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Steel and Steel Alloys (continued)	
1 cont.	K03103	G	ASTM- A414
	K03200	All types, grades, & classes	ASTM- A696
	K03501	All types, grades, & classes	ASTM- A106, A210, A234
	K03502	All types, grades, & classes	ASTM- A181
	K03503	C	ASTM- A178
	K03504	All types, grades, & classes	ASTM- A105, A695
	K03505	C2	ASTM- A557
	K03506	All types, grades, & classes	ASTM- A266, A541
	K04001	Type II	ASTM- A372
	K05001	Cl. 3	ASTM- A266
	K11224	Alloy Steel	ASTM- A562
	K11500	Alloy Steel	ASTM- A587
	K11831	A	ASTM- A724
	K12001	B	ASTM- A737, A738
	K12031	B	ASTM- A724
	K12447	All types, grades, & classes	ASTM- A738
	K13502	Cl. 1	ASTM- A508
3	J11522	CP15	ASTM- A426
	J11547	CP2	ASTM- A426
	J12521	CP1	ASTM- A426
	J12522	WC1	ASTM- A352
	K11422	T1b	ASTM- A209, A250
	K11522	T1	ASTM- A161, A209, A250
	K11547	T2	ASTM- A213, A250
	K11578	P15	ASTM- A335
	K11820	A	ASTM- A204
	K12020	B	ASTM- A204
	K12021	A	ASTM- A302
	K12022	B	ASTM- A302
	K12023	T1a	ASTM- A209, A250
	K12039	C	ASTM- A302
	K12042	Cl. 3 &3a	ASTM- A508
	K12045	Cl. 3 &3a	ASTM- A541
	K12054	D	ASTM- A302
	K12122	F2	ASTM- A182
	K12143	Gr. 2, Cl. 1 & 2	ASTM- A387
	K12320	C	ASTM- A204
	K12520	F1	ASTM- A336
	K12521	Type A, Cl.1 & 2	ASTM- A533
	K12529	Type D, Cl.1 & 2	ASTM- A533

Appendix C

M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Steel and Steel Alloys (continued)	
3 cont.	K12539	Type B, Cl.1 & 2	ASTM- A533
	K12554	Type C, Cl.1 & 2	ASTM- A533
	K12765	Cl. 2 & 2a	ASTM- A541
	K12766	Cl. 2 & 2a	ASTM- A508
	K12821	WP1	ASTM- A234
	K12822	F1	ASTM- A182
4	J11562	CP12	ASTM- A426
	J12072	WC6	ASTM- A217
	J12082	WC4	ASTM- A217
	K11267	4	ASTM- A333
	K11535	1	ASTM- A423
	K11540	2	ASTM- A423
	K11562	F12, Cl.1	ASTM- A182
	K11564	F12, Cl.2	ASTM- A182
	K11572	F11, Cl.1 & 2	ASTM- A182
	K11597	T11	ASTM- A199, A200, A213, A250
	K11742	A	ASTM- A202
	K11757	12, Cl.1 & 2	ASTM- A387
	K11789	11, Cl.1 & 2	ASTM- A387
	K11797	B11	ASTM- A739
	K12062	WP12, Cl.1	ASTM- A234
	K12542	B	ASTM- A202
5	J21890	WC9	ASTM- A217
	J22091	Gr. 8, Cl. A, B, & C	ASTM- A487
	J42045	C5	ASTM- A217
	J51545	CP5b	ASTM- A426
	J82090	C12	ASTM- A217
	K21390	B22	ASTM- A739
	K21590	All types, grades, & classes	ASTM- A182, A199, A200, A213, A234, A250, A335, A336, A369, A387, A508, A542
	K31509	T22	ASTM- A199, A200
	K31545	All types, grades, & classes	ASTM- A182, A199, A200, A213, A335, A336, A369, A387
	K31830	F3V	ASTM- A508, A541, A832
	K41245	T5c	ASTM- A213
	K41545	All types, grades, & classes	ASTM- A182, A199, A200, A213, A234, A335, A336, A369, A387
	K42544	F5a	ASTM- A182, A336
	K51545	P5b	ASTM- A335
	K81590	T9	ASTM- A199, A200, A213

Appendix C

M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Steel and Steel Alloys (continued)	
6	J91151	CA15M Cl.A	ASTM- A487, A743
	J91540	CA6NM Cl.A & B	ASTM- A352, A356, A487
	S41000	Type 410	AMS- 5504, 5505, 5591, 5613, 5776, 7493 ASTM- A176, A193, A194, A240, A268, A276, A314, A473, A479, A493, A511, A580
	S41026	F6b	ASTM- A182
	S41500	F6NM	ASTM- A176, A182, A240, A268, A479, A815
	S42900	F429	ASTM- A176, A182, A240, A268, A276, A314, A473, A493, A511, A554, A815
7	S40500	Type 405	ASTM- A176, A240, A268, A276, A473, A479, A511, A580
	S40800	--	ASTM- 268
	S40900	Type 409	ASTM- A176, A240, A268, A791, A803
	S41008	Type 410S	ASTM- A176, A240, A473
	S43000	Type 430	AMS- 5503, 5627 ASTM- A176, A182, A240, A268, A276, A314, A473, A479, A493, A511, A554, A791, A815
	S43035	Type 439	ASTM- A240, A268, A479, A791, A803
	S44400	18Cr-2Mo	ASTM- A176, A240,A276, A479, A791, A803
8	J92500	CF-3	ASTM- A351, A743, A744
	J92600	CF-8	ASTM- A351, A743, A744
	J92710	CF-8C	ASTM- A351, A743, A744
	J92800	CF-3M	ASTM- A351, A744
	J92900	CF-8M	ASTM- A351, A743, A744
	J93400	CH-8	ASTM- A351
	J93402	CH-20	ASTM- A351, A743
	S20100	TP201	ASTM- A213, A240, A249, A412, A666
	S20200	202	ASTM- A213, A240, A249, A314, A412, A473, A666
	S20910	Type XM-19	AMS- 5764 ASTM- A182, A184, A213, A240, A249, A269, A312, A403, A412, A479, A580, A813
	S21600	216	ASTM- A240, A479, A492
	S21603	216L	ASTM- A240, A479, A492
	S21800	Nitronic 60	AMS- 5848 ASTM- A193, A194, A240, A276, A479, A555, A580
	S21904	21-6-9 LC	AMS- 5562, 5595, 5656 ASTM- A182, A276, A314, A412, A473, A479, A580,
	S24000	**18-3-Mn**	A666
	S30200	**302**	ASTM- A240, A249, A269, A312, A412, A479, A580, A688, A813, A814 AMS- 5515, 5516, 5600, 5636, 5637, 5688, 5693, 7210, 7241 ASTM- A167, A240, A276, A313, A314, A368, A473, A478, A479, A492, A493, A511, A554, A580, A566, A813, A814, A851

Appendix C

M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
			Steel and Steel Alloys (continued)
8 CONT.	S30400	304	AMS- 5501, 5513, 5560, 5563 - 5567, 5639, 5697, 7228,7245 ASTM- A167, A182, A193, A194, A213, A240, A249, A269, A270, A271, A276, A312, A313, A314, A320, A336, A358, A368, A376, A409, A430, A473, A478, A479, A492, A493, A511, A554, A580, A632, A666, A688, A793
	S30403	304L	AMS- 5511, 5647 ASTM- A167, A182, A213, A240, A249, A269, A270, A276, A312, A314, A336, A403, A473, A478, A479, A511, A554, A580, A632, A666, A688, A774, A778, A813, A814, A851
	S30409	304H	ASTM- A182, A213, A240, A249, A271, A312, A336, A358, A376, A403, A430, A479, A813, A814
	S30451	304N	ASTM- A182, A213, A240, A249, A312, A358, A376, A403, A430, A479, A666, A688, A813, A814
	S30453	304LN	ASTM- A182, A213, A240, A249, A269, A276, A312, A336, A376, A403, A479, A666, A688, A813, A814
	S30600	18-15	ASTM- A182, A240, A269, A312, A358, A479
	S30815	253 MA	ASTM- A213, A240, A249, A276, A312, A473, A479, A813, A814
	S30908	309S	AMS- 5523, 5574, 5650, 7490 ASTM- A167, A213, A240, A249, A276, A312, A314, A473, A479, A511, A554, A580, A813, A814
	S30909	309H	ASTM- A240, A269, A312, A336, A479
	S30940	309 S Cb	ASTM- A213, A240, A249, A312, A478, A479, A554, A580, A813, A814
	S30941	309HCb	ASTM- A213, A240, A249, A312
	S31000	310	ASTM- A167, A182, A213, A240, A249, A276, A314, A336, A358, A403, A409, A473, A580, A632
	S31008	310S	ASTM- A167, A213, A240, A249, A276, A312, A314, A473, A479, A511, A554, A580, A813, A814
	S31009	310H	ASTM- A213, A240, A249, A312, A336, A479
	S31040	310Cb	ASTM- A213, A240, A249, A312, A478, A479, A814
	S31254	254 SMO	ASTM- A182, A240, A249, A312, A479, A813, A814
	S31600	316	AMS- 5524, 5573, 5648, 5690, 5696, 7490 ASTM- A167, A182, A193, A194, A213, A240, A249, A269, A270, A271, A276, A312, A313, A314, A320, A336, A358, A368, A376, A403, A409, A430, A473, A478, A479, A492, A493, A511, A554, A580, A632, A666, A688, A771, A813, A814, A826
	S31603	316L	ASTM- A167, A182, A213, A240, A249, A269, A270, A276, A312, A314, A336, A403, A473, A478, A479, A511, A554, A580, A632, A666, A688, A774, A778, A813, A814
	S31609	316H	ASTM- A182, A213, A240, A249, A271, A312, A336, A358, A376, A403, A430, A479, A813, A814
	S31635	316Ti	ASTM- A240, A368, A478, A479

Appendix C

M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
			Steel and Steel Alloys (continued)
8 cont.	S31640	316Cb	ASTM- A240, A368, A478, A479
	S31651	316N	ASTM- A182, A213, A240, A249, A276, A312, A336, A358, A376, A403, A430, A479, A666, A688, A813, A814
	S31653	316LN	ASTM- A182, A193, A194, A213, A240, A249, A269, A276, A312, A320, A336, A376, A403, A479, A688, A813, A814
	S31700	317	ASTM- A167, A182, A213, A240, A249, A269, A276, A312, A314, A403, A409, A473, A478, A511, A554, A580, A632, A813, A814
	S31703	317L	ASTM- A167, A182, A213, A240, A249, A312, A774, A778, A813, A814
	S31725	317LM	ASTM- A167, A182, A213, A240, A249, A269, A276, A312, A358, A376, A409, A479
	S31726	317L4	ASTM- A167, A182, A213, A240, A249, A269, A276, A312, A358, A376, A409, A479
	S31753	317LN	ASTM- A167, A240
	S32100	321	ASTM- A167, A182, A193, A194, A213, A240, A249, A269, A271, A276, A312, A314, A320, A336, A358, A376, A403, A409, A430, A473, A479, A511, A554, A580, A632, A774, A778, A813, A814
	S32109	321H	ASTM- A182, A213, A240, A249, A271, A312, A336, A376, A403, A430, A479, A813,
	S33100	F-10	A814
	S34700	347	ASTM- A182
			ASTM- A167, A182, A193, A194, A213, A240, A249, A269, A271, A276, A312, A314, A320, A336, A358, A376, A403, A409, A430, A473, A479, A511, A554, A580, A632,
	S34709	347H	A774, A778, A813, A814
			ASTM- A182, A213, A240, A249, A271, A312, A336, A376, A403, A430, A473, A479,
	S34800	348	A813, A814
			ASTM- A167, A182, A213, A240, A249, A269, A276, A312, A314, A336, A358, A376,
	S34809	348H	A403, A409, A479, A580, A632, A813, A814
	S38100	18-18-2	ASTM- A182, A213, A240, A249, A312, A336, A479, A813, A814
			ASTM- A167, A213, A240, A249, A269, A312, A813, A814
9	J22500	LC2	ASTM- A352
	J31550	LC3	ASTM- A352
	J41500	LC4	ASTM- A352
	K13050	LF5	ASTM- A350
	K21703	A	ASTM- A203
	K21903	7	ASTM- A333, A334
	K22035	WPR	ASTM- A234
	K22036	LF9	ASTM- A350
	K22103	B	ASTM- A203
	K31718	D	ASTM- A203
	K31918	3	ASTM- A333, A334
	K32018	E	ASTM- A203

Appendix C

M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Steel and Steel Alloys (continued)	
10	J03004	Gr.1, Cl.A & B	ASTM- A216, A757
	J13005	Gr.2, Cl.A & B	ASTM- A487
	J13047	Gr.4, Cl.A & B	ASTM- A487
	J93345	CE8MN	ASTM- A890
	J93370	CD4Mcu	ASTM- A744
	K02900	--	ASTM- A612
	K12047	T17	ASTM- A213
	K12524	C	ASTM- A225
	S31200	F50	ASTM- A182, A240, A789, A790
	S31803	F51	ASTM- A182
	S32900	Type 329	ASTM- A240, A268, A789, A790
	S32950	7 Mo Plus	ASTM- A240, A268, A789, A790
	S44600	TP446-2	ASTM- A176, A286, A276, A314, A473, A511, A580, A815
	S44626	Type XM-33	ASTM- A176, A240, A268, A791, A803
	S44627	FXM-27Cb	ASTM- A176, A182, A240, A276, A314, A336, A479, A731, A791, A803
	S44635	25-4-4	ASTM- A176, A240, A268, A791, A803
	S44660	26-3-3	ASTM- A176, A240, A268, A791, A803
	S44700	29-4	ASTM- A176, A240, A268, A479, A493, A511, A580, A791, A803
	S44800	29-4-2	ASTM- A176, A240, A268, A276, A479, A493, A511, A791, A803
11	J13047	Gr.4, Cl. B & E	ASTM- A487
	J42215	LC2-1	ASTM- A532
	K11576	F	ASTM- A514, A517, A592
	K11625	J	AMS- 6386 ASTM- A514, A517
	K11630	B	AMS- 6386 ASTM- A514, A517
	K11695	E	ASTM- A592
	K11856	A	AMS- 6386 ASTM- A514, A517, A592
	K12521	Type A, Cl.3	ASTM- A533
	K12529	Type D, Cl.3	ASTM- A533
	K12539	Type B, Cl.3	ASTM- A533
	K12554	Type C, Cl.3	ASTM- A533
	K21604	E	ASTM- A514, A517
	K21650	P	ASTM- A514, A517
	K22375	Cl.4 & Cl.4A	ASTM- A508
	K41583	--	ASTM- A645
	K42365	Cl.5 & CL.5A	ASTM- A508
	K71340	Type II	ASTM- A522, A553
	K81340	8	ASTM- A333, A334

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M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
			Steel and Steel Alloys (continued)
12	G41300	4130	AMS- 6348, 6350, 6351, 6360, 6361, 6362, 6370, 6371, 6373, 6374, 6528, 7496 ASTM- A322, A331, A506, A507, A513, A519, A646, A829
	G41350	4135	AMS- 6352, 6365, 6372 ASTM- A331, A519, A829
	G41400	4140	AMS- 6349, 6381, 6382, 6390, 6395, 6529 ASTM- A322, A331, A506, A513, A519, A646, A711, A829
	G41500	4150	ASTM- A322, A331, A519, A711
	G43400	4340	AMS- 6359, 6409, 6414, 6415, 6454 ASTM- A322, A331, A506, A519, A646, A711, A829
	G86300	8630	AMS- ASTM- A322, A331, A513, A519, A646, A752, A829
	K24728	D6AC	AMS- 6431, 6432, 6438, 6439 ASTM- A579
	K44315	300M	AMS- 6417, 6419 ASTM- A646
	T20811	H11	AMS- 6437, 6485, 6487, 6488 ASTM- A579, A681
13	S13800	PH 13-8Mo	AMS- 5629, 5864 ASTM- A564, A693, A705
	S15700	PH 15-7Mo	AMS- 5520 ASTM- A564, A579, A693, A705
	S17400	17-4PH	AMS- 5604, 5622, 5643 ASTM- A564, A693, A705
	S17700	17-7PH	AMS- 5528, 5529, 5568, 5644, 5673, 5678 ASTM- A313, A564, A579, A693, A705
	S35000	AM-350	AMS- 5546, 5548, 5554, 5745 ASTM- A579,A693
	S35500	AM-355	AMS- 5547, 5549, 5743, 5744 ASTM- A564, A579,A693, A705
	S45000	Custom 450	AMS- 5763, 5773, 5859, 5863 ASTM- A564, A693, A705
	S45500	Custom 455	AMS- 5578, 5617, 5672, 5860 ASTM- A313, A564, A693, A705
	S66286	A-286	AMS- 5525, 5726, 5731, 5732, 5734, 5737, 5804, 5805, 5853, 5858, 5895, 7235 ASTM- A638
	S66545	W545	ASTM- A453
			Aluminum and Aluminum-Base Alloys
21	A91060	1060	AMS- 4000 ASTM- B209, B210, B221, B234, B241
	A91100	1100	AMS- 4001, 4003, 4062, 4102, 4180, 7220 ASTM- B209, B221, B241
	A93003	3003	AMS- 4006,4008, 4010, 4065, 4067 ASTM- B209, B210, B221, B234, B241, B247
22	A93004	3004	AMS- ASTM- B209,
	A95052	5052	AMS- 4004,4015, 4016, 4017, 4096, 4070, 4071, 4114, 4175, 4178, 4348 ASTM-
	A95154	5154	B209
	A95652	5652	ASTM- B209, B210, B221
			ASTM- B209
23	A96061	6061	
			AMS- 4009, 4025 - 4027, 4079 - 4083, 4113, 4115 - 4117, 4127, 4128, 4146, 4150, 4160, 4161, 4172, 4173, 4248, 4312 ASTM- B209, B210, B211, B221, B234, B241,
	A96063	6063	B247, B308
			AMS- 4156 ASTM- B210, B221, B241

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M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Aluminum and Aluminum-Base Alloys (continued)	
25	A95083	5083	AMS- 4056, 4057, 4058, 4059 ASTM- B209, B221, B241, B247
	A95086	5086	ASTM- B209, B241
	A95456	5456	AMS- ASTM- B209, B221, B241
26	A03560	356	AMS- 4217, 4260, 4261, 4284, 4285, 4286 ASTM- B26, B108
	A92014	2014	AMS- 4028, 4029, 4121, 4133, 4134, 4153, 4314 ASTM- B209, B210, B211, B221, B241, B247
	A92219	2219	AMS- 4031, 4066, 4143, 4144, 4162, 4163, 4313 ASTM- B209, B211, B221, B241, B247, B316
		Copper and Copper-Base Alloys	
31	C10200	OF	AMS- 4501, 4602, 4701 ASTM- B42, B75, B133, B395
	C10400	OFS	ASTM- B152
	C10500	OFS	ASTM- B152
	C10700	OFS	ASTM- B152
	C11000	ETP	ASTM- B133,
	C12000	DLP	ASTM- B42, B75, B111, B133, B359, B395
	C12200	DHP	ASTM- B42, B75, B111, B133, B152, B359, B395, B543
	C12300	DHP	ASTM- B152
	C12500	FRTP	ASTM- B133, B152
	C14200	DPA	ASTM- B75, B111, B133, B152, B359, B395
	C19200	--	ASTM- B111, B359
32	C23000	Red Brass, 85%	ASTM- B43, B111, B135, B359, B395, B543,
	C28000	Muntz Metal, 60%	ASTM- B111
	C36500	Leaded Muntz metal Uninhibited	ASTM- B171
	C36600	Leaded Muntz metal, Arsenical	ASTM- B171
	C36700	Leaded Muntz metal, Antimonial	ASTM- B171
	C36800	Leaded Muntz metal, Phos.	ASTM- B171
	C44300	Admiralty, Arsenical	ASTM- B111, B171, B359, B395, B543
	C44400	Admiralty, Antimonial	ASTM- B111, B171, B359, B395, B543
	C44500	Admiralty, Phosphorized	ASTM- B111, B171, B359, B395, B543
	C46400	Naval Brass	ASTM- B171
	C46500	Naval Brass, Arsenical	ASTM- B171
	C46600	Naval Brass, Antimonial	ASTM- B171
	C46700	Naval Brass, Phosphorized	ASTM- B171
	C68700	Aluminum Brass, Arsenical	ASTM- B111, B359, B395, B543

Appendix C

M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Copper and Copper-Base Alloys (continued)	
33	C65100	Low Silicon Bronze B	ASTM- B96, B98, B315,
	C65500	High Silicon Bronze A	AMS- 4615, 4665 ASTM- B96, B98, B315
34	C70400	Copper-Nickel, 5%	ASTM- B111, B359,
	C70600	Copper-Nickel,10%	ASTM- B111, B122, B151, B171, B359, B395, B466, B467, B453
	C71000	Copper-Nickel, 20%	ASTM- B111, B122, B206, B359, B395, B466, B467, B453, B694
	C71500	Copper-Nickel, 30%	ASTM- B111, B122, B151, B171, B359, B395, B466, B467, B453
	C71640	Copper-Nickel	ASTM- B111, B543, B552
	C72200	Copper-Nickel	ASTM- B111, B122, B171, B359, B395, B466, B453
	C96200	Cast Copper-Nickel	ASTM- B30,
	C60800	Aluminum Bronze	ASTM- B111, B359, B395
	C61400	Aluminum Bronze D	ASTM- B111, B150, B169, B171, B315, B432, B608,
	C62300	Aluminum Bronze	ASTM- B124, B150, B283
	C63000	Aluminum Bronze	ASTM- B124, B150, B171, B283,
	C64200	Aluminum Bronze	ASTM- B124, B150, B283,
		Nickel and Nickel-Base Alloys	
41	N02200	Nickel 200	ASTM- B160, B161, B162, B163, B366, B725, B730
	N02201	Nickel 201	AMS- 5553 ASTM- B160, B161, B162, B163, B366, B725, B730
42	N04400	Monel 400	AMS- 4544, 4574, 4575, 4675, 4730, 4731, 7233 ASTM- B127, B163, B164, B165, B366, B564
	N04405	Monel 405	AMS- 4674, 7234 ASTM- B164
43	N06002	Hastelloy X	AMS- 5390, 5536, 5587, 5588, 5754, 5798, 7237 ASTM- B366, B435, B572, B619, B622, B626
	N06600	Inconel 600	AMS- 5540, 5580, 5665, 5687, 7232 ASTM- B163, B166, B167, B168, B516, B517, B564
	N06625	Inconel 625	AMS- 5401, 5402, 5581, 5599, 5666, 5837,7490 ASTM- B366, B443, B444, B446, B704, B705
	N06690	Inconel 690	ASTM- B163, B166, B167, B168
44	N06022	Hastelloy C-22	ASTM- B366, B564, B574, B575, B619, B622, B626
	N06455	Hastelloy C4	ASTM- B574, B575, B619, B622, B626
	N10001	Hastelloy B	AMS- 5396 ASTM- B333, B335, B366, B619, B622, B626
	N10002	Hastelloy C	AMS- 5388, 5389, 5530, 5750
	N10003	Hastelloy N	AMS- 5607, 5771 ASTM- B366, B434, B573
	N10276	Hastelloy 276	ASTM- B366, B564, B574, B575, B619, B622, B626
	N10665	Hastelloy B2	AMS- ASTM- B333, B335, B366, B619, B622, B626

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M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Nickel and Nickel-Base Alloys (continued)	
45	N06007	Hastelloy G	ASTM- B366, B581, B582, B619, B622, B626
	N06030	Hastelloy G-30	ASTM- B366, B581, B582, B619, B622, B626
	N06975	Hastelloy G-2	ASTM- B581, B582, B619, B622, B626
	N06985	Hastelloy G-3	ASTM- B581, B582, B619, B622, B626
	N08007	ACI CN-7M	ASTM- A351
	N08020	Carpenter Cb3	ASTM- B366, B581, B582, B619, B622, B626
	N08024	Columbium Stabilized	ASTM- B581, B582, B619, B622, B626
	N08026	Carpenter 20Mo6	ASTM- B581, B582, B619, B622, B626
	N08028	Sanicro 28	ASTM- B668, B709
	N08320	Haynes 20 Mod	ASTM- B619, B620, B621, B622, B626
	N08366	AL-6X	ASTM- B675, B676, B688, B690, B691
	N08367	AL-6XN	ASTM- B472, B564, B675, B676, B688, B690, B691, B804
	N08700	JS 700	ASTM- B599, B672
	N08800	Incoloy 800	AMS- 5766, 5871 ASTM- B163, B407, B408, B409, B514, B515
	N08810	Incoloy 800H	ASTM- B163, B407, B408, B409, B514, B564
	N08811	Incoloy 800HT	ASTM- B407, B408, B409
	N08825	Incoloy 825	ASTM- B163, B423, B424, B425, B456, B704, B705
	N08904	Fe-Ni-Cr alloy	ASTM- B625, B649, B673, B674, B677
	N08925	--	ASTM- B625, B649, B673,B674, B677
	R30556	HS 556	AMS- 5874 ASTM- B366, B435, B572, B619, B622, B626
46	N08330	RA-330	AMS- 5592, 5716 ASTM- B366, B536, B546, B710, B739
47	N06230	Alloy No. 230	ASTM- B435, B572, B619, B622, B626
48	N05500	Monel K500	AMS- 4676
	N06601	Hastelloy F	ASTM- B366
	N07001	Waspaloy	AMS- 5544, 5586, 5704, 5706, 5707, 5708 ASTM- B637
	N07031	Pyromet 31	(SAE J775)
	N07041	Rene 41	AMS- 5399, 5545, 5712, 5713, 5800, 7469
	N07080	Nimonic 80A	ASTM- B637
	N07252	M252	ASTM- B637
	N07500	Udimet 500	AMS- 5384, 5751, 5753 ASTM- B637
	N07718	Inconel 718	AMS- 5383, 5589, 5596, 5597, 5662 ASTM- B637, B670
	N07750	Inconel X750	AMS- 5542, 5582, 5583, 5598, 5667, 5668, ASTM- B637
	N09706	Inconel 706	AMS- 5605, 5606, 5701, 5702, 5703
	N09901	Inconel 901	AMS- 5660, 5661
	N09902	Inconel 902	AMS- 5221, 5223, 5225

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M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Titanium and Titanium-Base Alloys	
51	R50250	Grade 1	ASTM- B265, B337, B338, B348, B381
	R50400	Grade 2	AMS- 4902, 4941, 4942 ASTM- B265, B337, B338, B348, B367, B381
	R52400	Grade 7	ASTM- B265, B337, B338, B348, B381
52	R50550	Grade 3	ASTM- B265, B337, B338, B348, B381
	R53400	Grade 12	ASTM- B265, B337, B338, B348, B381
53	R56320	Grade 9	AMS- 4943, 4944 ASTM- B265, B337, B338, B348, B381
55	R54250	Ti-5Al-2.5Sn	ASTM- B367
	R54620	Ti-6Al-2Sn-4Zr-2Mo	AMS- 4919, 4952, 4975, 4976
	R54810	Ti-8Al-1Mo-1V	AMS- 4915, 4916, 4933, 4955, 4972, 4973
	R56210	Ti-6Al-2Cb-1Ta-1Mo	None
	R56260	Ti-6Al-2Sn-4Zr-6Mo	AMS- 4981
	R56400	Ti-6Al-4V	AMS- 4905, 4906, 4911, 4920,4930, 4931, 4934, 4935, 4954, 4965, 4967, 4993 ASTM- B265, B348, B367, B381
	R56620	Ti-6Al-6V-2Sn	AMS- 4918, 4936, 4971, 4978, 4979
	R58640	Ti-3Al-8V-6Cr-4Mo-4Zr	AMS- 4957, 4958
		Zirconium and Zirconium-Base Alloys	
61	R60702	Grade R60702	ASTM- B493, B494, B495, B523, B550, B551, B653, B658, B752
62	R60705	Grade R60705	ASTM- B493, B495, B523, B550, B551, B653, B658, B572
		Cobalt and Cobalt-Based Alloys	
81	R30006	Stellite 6	AMS- 5373, 5387, 5788
	R30021	Stellite 21	AMS- 5385
	R30023	Stellite 23	AMS- 5375
	R30027	Stellite 27	AMS- 5378
	R30030	Stellite 30	AMS- 5380
	R30031	Stellite 31	AMS- 5382, 5789
	R30188	Alloy 188	AMS- 5608, 5772, 5801
	R30605	L605	AMS- 5537, 5759, 5796, 7236
	R30816	S816	ASTM- B639

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M-Numbers - Grouping of Base Metals for Qualification

M-No.	UNS Number	Common Description	ASTM & AMS Numbers
		Magnesium and Magnesium-Base Alloys	
91	M10100	AM100A	AMS- 4455, 4483 ASTM- B93, B199, B275, B403
	M11311	AZ31B	AMS- 4375, 4376, 4377, 4382 ASTM- B90, B91, B107, B275
	M11610	AZ61A	AMS- 4350 ASTM- B90, B91, B107, B275
	M11800	AZ80A	AMS- 4360 ASTM- B91, B107, B275
	M11910	AZ91A	AMS- 4490 ASTM- B94, B275
	M11920	AZ92A	AMS- 4434, 4453, 4484 ASTM- B80, B93, B199, B275, B403
	M12330	EZ33A	AMS- 4442 ASTM- B80, B93, B199, B275, B403
	M13210	HM21A	AMS- 4363, 4383, 4390 ASTM- B90, B91, B275
	M13310	HK31A	AMS- 4384, 4385, 4445 ASTM B80, B199, B275, B403
	M13312	HM31A	AMS- 4388, 4389 ASTM- B275
	M13320	HZ32A	AMS- 4447 ASTM- B80, B93, B275
	M14141	LA141A	AMS- 4386, 4397 ASTM- B90, B275
	M16620	ZH62A	AMS- 4483 ASTM- B80, B93, B275
	M18220	QE22A	AMS- 4418 ASTM- B80, B93, B199, B403